

INSTRUCTION MANUAL

96

Electronic Services - Los Angeles



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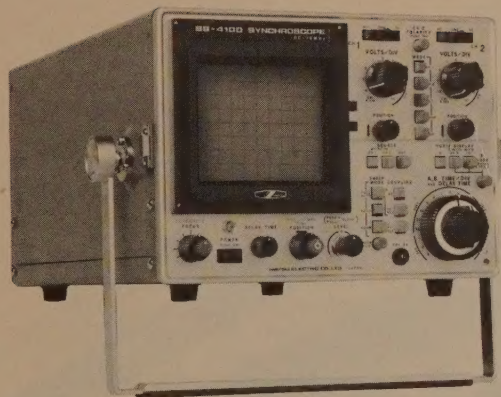
SYNCHROSCOPE
SS-4100

SYNCHROSCOPE
SS-4100
SS-4100G

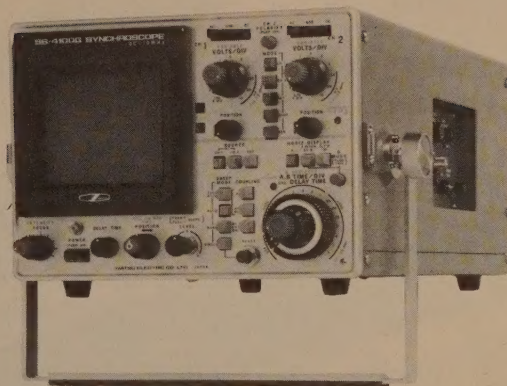


IWATSU ELECTRIC CO., LTD.





SS-4100



SS-4100G

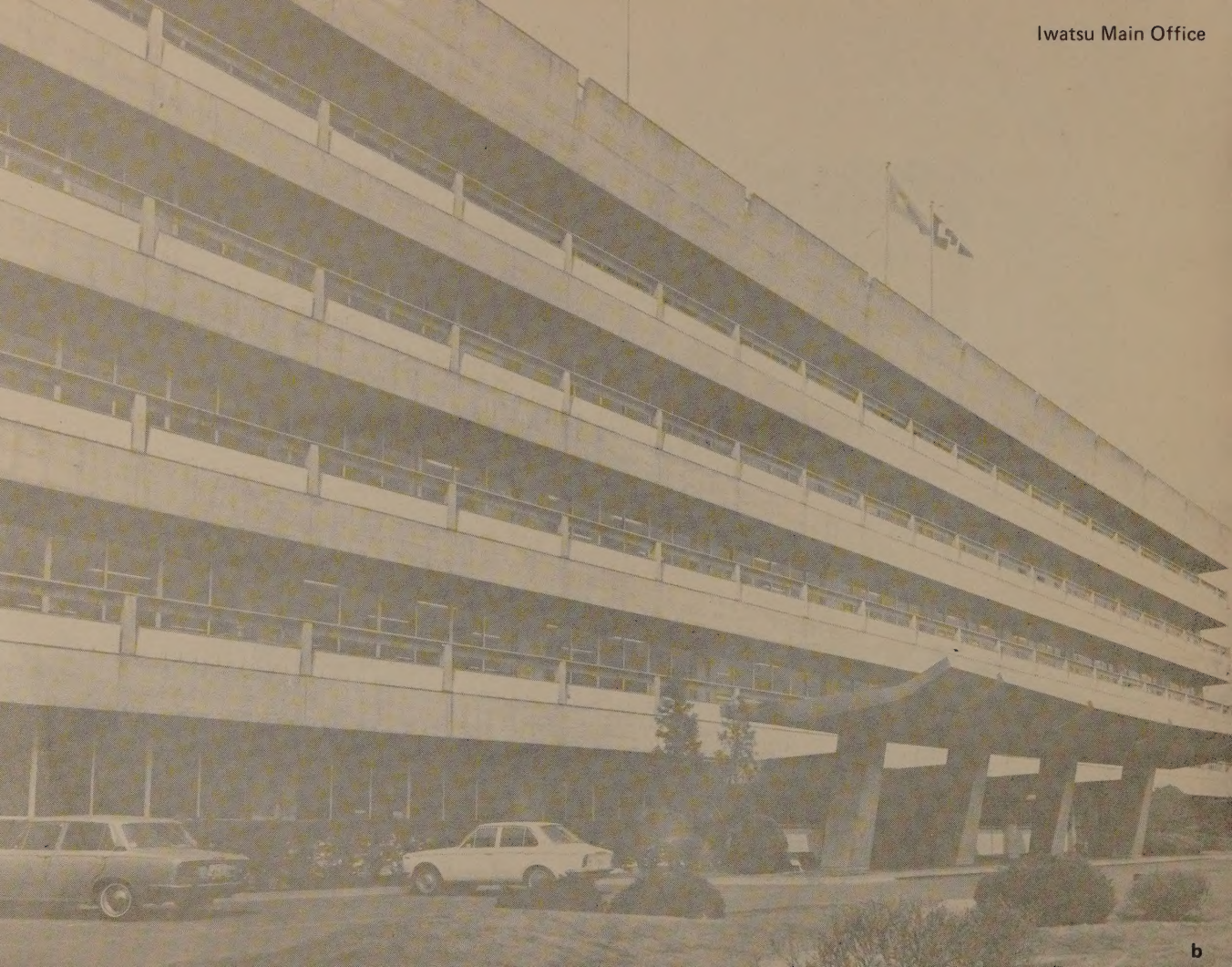
INSTRUCTION MANUAL

SYNCHROSCORE
SS-4100
SS-4100G

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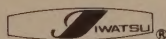
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July 1975 <5>



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COMMON INSTRUCTION MANUAL

This instruction manual is applicable in common to both SS-4100 and SS-4100G Synchrosopes. The manual is simultaneously applicable to both models unless specified otherwise as <SS-4100 only> or <SS-4100G only> or with other indications.

The SS-4100 is designed for maintenance of computers and peripheral apparatus, and the SS-4100G for other general purposes. The differences between the two models are as tabulated below:

Functions	SS-4100	SS-4100G
VARIABLE (Fine control of vertical sensitivity)	No.	Yes.
UNCALIB (Vertical sensitivity uncalibration lamp)	No.	Yes.
AND TRIG	Yes.	No.
LINE TRIG	No.	Yes.
SINGLE SWEEP	No.	Yes.
A VARIABLE (Fine control of A sweep time)	No.	Yes.
A UNCALIB (A sweep uncalibration lamp)	No.	Yes.

ABBREVIATIONS AND SYMBOLS

Abbreviations and symbols used in this manual are as follows:

◆ For units:

A	ampere
dB	decibel
div (DIV)	division
g	gram
Hz	hertz
m	meter
sec (SEC)	second
F	farad
V	volt
W	watt
Ω	ohm
rms	root mean square
p-p	peak to peak

◆ For orders:

T	tera	$10^{12} = 1\,000\,000\,000\,000$
G	giga	$10^9 = 1\,000\,000\,000$
M	mega	$10^6 = 1\,000\,000$
k	kilo	$10^3 = 1\,000$
h	hecto	$10^2 = 100$
da	deca	$10^1 = 10$
d	deci	$10^{-1} = 0.1$
c	centi	$10^{-2} = 0.01$
m	mili	$10^{-3} = 0.001$
μ	micro	$10^{-6} = 0.000\,001$
n	nano	$10^{-9} = 0.000\,000\,001$
p	pico	$10^{-12} = 0.000\,000\,000\,001$

◆ Others:

AC	alternate current
ADJ	adjust
ALT	alternate
ASTIG	astigmatism
AUTO (Auto)	automatic
BAL	balance
CAL	calibrated
CH 1	channel 1
CH 2	channel 2
CHOP	chopped
DC	direct current
DLY'D	delayed
EXT	external
GND	ground (earth)
HF REJ	high frequency reject
HORIZ	horizontal
ILLUM	illumination
INT	internal
INTEN	intensity
INV	inverter
MAG	magnifier
NORM	normal
ORTHO	orthogonality
TRIG	trigger
VERT	vertical

GENERAL

The SS-4100/SS-4100G synchroscope is a very compact, lightweight synchroscope featuring an exceptional ease of operation and high portability. It covers a frequency range of DC to 10 MHz.

The vertical deflection system is of a 2-channel system with electronic switching, with a bandwidth of DC to 10 MHz and a sensitivity of 10 mV/div for both channels. A signal delay feature also is incorporated to facilitate observation of rise-up sections of pulse waves.

The horizontal deflection system is capable of stable sweep triggering for a frequency range of DC to 10 MHz. It employs a new FULL AUTO triggering system, eliminating complicated triggering procedure. Since the trigger

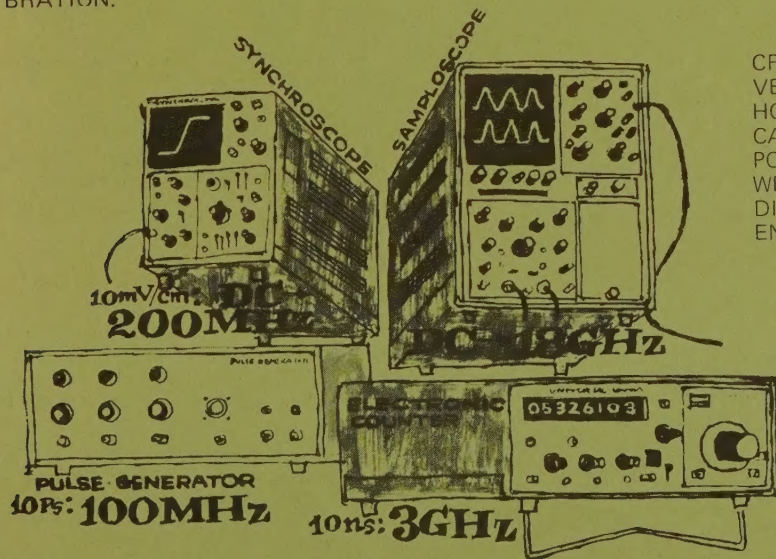
circuit is common for both A and B channels, sweep magnification with delay can be easily made. A variable sweep length function and a sweep stop function also are incorporated. Additional features are an AND TRIG function for the SS-4100, and a single-sweep function and a LINE TRIG function for the SS-4100G. Thus, the application flexibility of these synchscopes is greatly improved.

The CRT is of a 4-inch rectangular type and is provided with a non-parallax inner-surface graticule. The effective graticule dimensions are 8 vertical divisions and 10 horizontal divisions (1 division = 8 mm). An acceleration voltage of 6.5 kV produces highly luminous traces and sharp images are displayed without parallax for a wide range on the CRT screen.

1

SECTION 1 PERFORMANCE CHARACTERISTICS

This section briefly describes the synchroscope's performance characteristics and accuracies which are to be ensured for accurate measurements. For setups and calibrations for ensuring these characteristics and accuracies, refer to SECTION 6 OPERATION CHECK AND CALIBRATION.



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CRT CIRCUIT

Cathode-ray tube	
Construction	4-inch rectangular, non-parallax inner-surface graticule
Effective screen area	8 vertical divisions x 10 horizontal divisions (1 division = 8 mm)
Acceleration voltage	Approx. 6.5 kV
External intensity modulation	
Input voltage	2 Vp-p or over (Positive voltage for brightening and negative voltage for darkening)
Frequency range	10 Hz — 10 MHz
Input resistance	Approx. 1 M Ω
Allowable input voltage	100 V (DC + AC peak)

VERTICAL DEFLECTION SYSTEM

(The SS—4100 is for 2-channel display. Performances of both channels are identical and are as follows.)

Sensitivity	10 mV/div — 10 V/div 1-2-5 step, selectable in 10 steps Accuracy $\pm 2\%$ (20°C — 30°C) $\pm 3\%$ (0°C — 40°C) $\pm 4\%$ (–10°C — 50°C) < SS—4100G only > 10 mV/div — 25 V/div Continuously variable with fine control
Frequency range	DC coupling DC — 10 MHz, –3 dB

Square wave characteristics

Rise time
Signal delay time

Input signal coupling
Input RC

Maximum allowable input voltage

Mode selection

AC coupling 4 Hz — 10 MHz, –3 dB

Overshoot:	3%
Rounding:	2%
Ringing:	1%
Matching distortion:	2%
Tilt, 1 MHz	2%
250 kHz	2%
100 kHz	2%
15 kHz	2%
60 Hz	2%

35 nsec.
27 nsec. or over (delay time as displayed on CRT screen)
AC, GND, DC
Direct coupling... 1 M $\Omega \pm 2\%$
30 pF ± 3 pF
With probe 10 M $\Omega \pm 3\%$
15 pF ± 1.5 pF

Direct coupling... 600 V
(DC + AC peak)
With probe 600 V
(DC + AC peak)

CH 1: CH 1 only
CH 2: CH 2 only
ALT: Alternate sweep of CH 1 and CH 2
CHOP: Chopped switching of CH 1 and CH 2 (switching frequency 200 kHz $\pm 20\%$)
ADD: (CH 1) $\pm$ (CH 2)

Polarity inversion	For CH 2 display only.	Trigger signal coupling	AC, (AC) HF REJ, DC EXT ONLY
Common mode rejection ratio	At 1 kHz sine wave 40:1 or better At 10 MHz sine wave 10:1 or better	External input RC AND trigger	1 M Ω $\pm$ 5%, 42 pF $\pm$ 5 pF (LOGIC) < for SS-4100 >
Linearity	Linearity variation caused by position variation $\pm$ 5% or better. Linearity variation caused by amplitude variation $\pm$ 5% or better.		The number inputs: Four diode inputs (normal logic only) Input voltage: +2.6V — +30 V Input resistance: Approx. 4.7 k Ω (when diode is conducting)
Drift	1 div/hour as measured 10 minutes after turning on the instrument power.		Rise time: Approx. 1 μ sec. Pulse width: 1 μ sec. or over Fall time: Approx. 30 nsec.

Triggering frequency range and minimum triggering level
SWEEP (A)
Sweep time

Refer to table 1-1.

HORIZONTAL DEFLECTION SYSTEM

Sweep system	Triggered sweep, Free running sweep
Sweep modes	A: A sweep (main sweep) A INT BY B: Delayed sweep DLY'D (B): Sweep delay

TRIGGERING

Trigger system	FULL AUTO, AUTO, and NORM < for SS-4100 > INT (CH 1, CH 2), EXT (NORM, LOGIC) < for SS-4100G > INT (CH 1, CH 2), EXT, LINE
Triggering mode	
Polarity	Positive or negative

Linearity
Sweep magnification
Maximum sweep time
Variable sweep length

0.5 μ sec/div — 0.5 sec/div
1-2-5 step, selectable in 19 steps.
Accuracy: $\pm$ 2% (20°C — 30°C)
 $\pm$ 3% (0°C — 40°C)
 $\pm$ 4% (-10°C — 50°C)
For 0.5 sec/div only,
 $\pm$ 5% (20°C — 30°C)
< SS-4100G only >
0.5 μ s/div — 1.25 μ s/div
Continuously variable with fine control
 $\pm$ 5%
10 times, accuracy $\pm$ 5%
50 nsec/div
Approx. 3.5 — 11 div

SECTION 1 PERFORMANCE CHARACTERISTICS

SWEEP (B)

Delay system

Continuous delay, triggered delay

Sweep time

0.5 μ sec/div — 0.5 sec/div

1-2-5 step, selectable in 19 steps

Accuracy: $\pm 2\%$ (20°C — 30°C)

$\pm 3\%$ (0°C — 40°C)

$\pm 4\%$ (-10°C — 50°C)

For 0.5 sec/div only,

$\pm 5\%$ (20°C — 30°C)

Linearity

$\pm 5\%$

Sweep magnification

10 times, accuracy $\pm 5\%$

Maximum sweep time

50 nsec/div

Delay time

1 μ sec — 5 sec

Delay jitter

1/20,000

SINGLE SWEEP

< SS-4100G only >

Both normal single-sweep and delayed single-sweep are possible.

SWEEP STOP

Possible for both A sweep and B sweep.

Table 1-1

Sweep mode	Trigger signal coupling	Sweep frequency	Minimum triggering level	
			INT. Amplitude on CRT screen (div.)	EXT. Input voltage (Vp-p)
FULL AUTO	AC	100 Hz — 5 MHz 5 — 10 MHz	1 2	1 1
	(AC) HF REJ	100 Hz — 10 kHz	1	1
	DC EXT ONLY	100 Hz — 10 MHz	—	1
AUTO	AC	50 Hz — 5 MHz 5 — 10 MHz	0.5 1	0.3 0.5
	(AC) HF REJ	50 Hz — 10 kHz	0.5	0.3
	DC EXT ONLY	50 Hz — 5 MHz 5 — 10 MHz	—	0.3 0.5
NORM	AC	30 Hz — 5 MHz 5 — 10 MHz	0.5 1	0.3 0.5
	(AC) HF REJ	30 Hz — 10 kHz	0.5	0.3
	DC EXT ONLY	DC — 5 MHz 5 — 10 MHz	—	0.3 0.5

CALIBRATION VOLTAGE OUTPUT

Signal waveform	Square wave
Repetition frequency	1 kHz, accuracy $\pm 0.5\%$
Duty ratio	Within 48:52
Output voltage	For sensitivity calibration 40 mV
	For probe calibration 4 V
	Accuracy $\pm 2\%$

POWER SUPPLY

Voltage Range Refer to table 1–2.

Table 1–2

Nominal voltage	Voltage range	Remarks
100 V AC 115 V AC	90 – 110 V 106 – 128 V	Standard: 100 V – 115 V switch selection
110 V AC 200 V AC 220 V AC 230 V AC	99 – 121 V 180 – 220 V 198 – 242 V 211 – 257 V	Option: (Notes) 100 V – 110 V 110 V – 115 V 200 V – 220 V 200 V – 230 V 220 V – 230 V

Notes: Line voltage change is optional. When voltages other than the standard is required, the above voltage are possible through internal wiring modification and switch selection.

Frequency range	50 – 400 Hz
Power consumption	Approx. 45 W (at 100 V AC)

WEIGHT

Main assembly Approx. 6.2 kg

With panel cover

Approx. 6.5 kg

DIMENSIONS

222 $\pm$ 2 wide, 158 $\pm$ 2 high,
345 $\pm$ 2 deep (mm)

ENVIRONMENTAL CONDITIONS

Ambient temperature	-10°C – +50°C
Humidity	90% R.H., 40°C
Storing temperature	-20°C – +70°C
Storing humidity	80% R.H., 70°C
Altitude	During operation... 5,000 meters Atmospheric pressure 428 mmHg

During
non-operation 15,000 meters
Atmospheric
pressure
87 mmHg

Vibration test

Double amplitude of 1 mm,
from 10 Hz to 33 Hz in 1
minute, 30 minutes for each of
the three major axes, total 90
minutes.

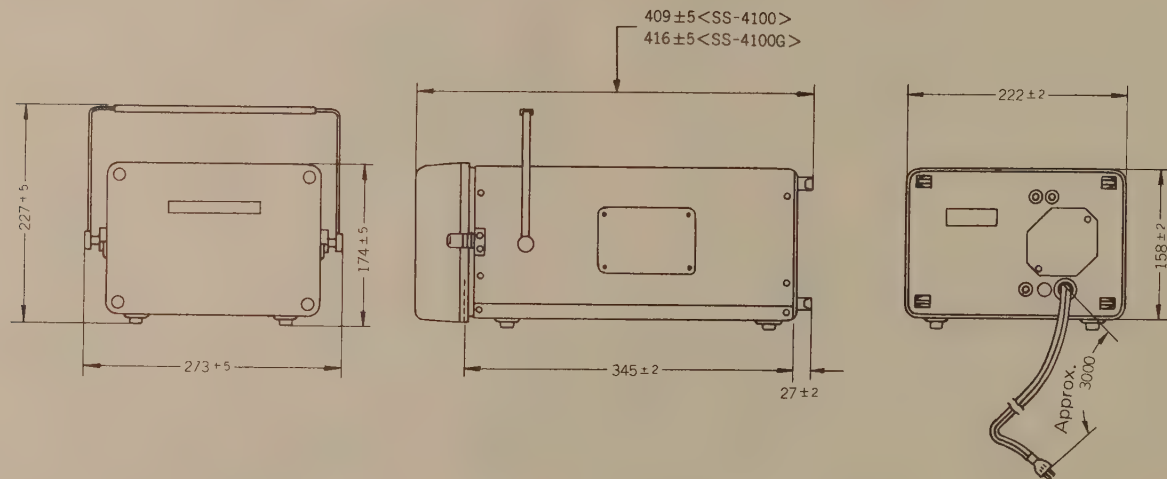
Shock test

One side of cabinet is lifted 5 cm
a hard wood bench (or 30° max.
in elevation angle), and natural
drop test is repeated 3 times for
each side.

Drop test

In shipment packing, instrument
is dropped from a height of
75 cm, for each plane and
corner, total 24 times.

Figure 1-1 Dimensions of SS-4100/SS-4100G



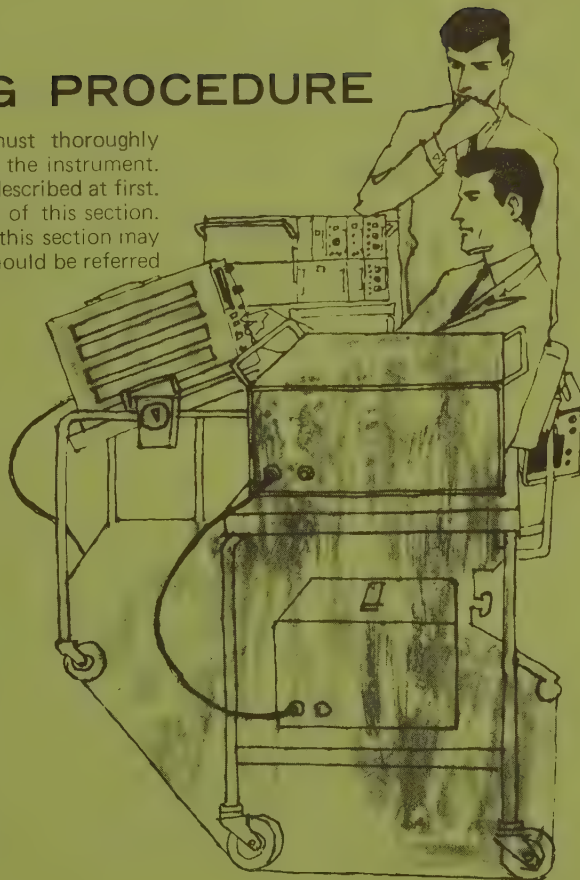
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SECTION 2 OPERATING PROCEDURE

For effective use of the SS-4100/SS-4100G, the user must thoroughly familiarize himself with the functions and operating procedure of the instrument.

In this section, handling precautions of panel controls will be described at first. Practical operating procedure will be described in the latter half of this section. When this instrument is to be used immediately, the first part of this section may be bypassed and the sub-section "OPERATING PROCEDURE" should be referred to.

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HANDLING PRECAUTIONS

CARRYING METHOD AND PANEL COVER

As seen in Fig. 2-1, there are two different ways of carrying this instrument. When the instrument is to be carried over a long distance, use a carrying bag and a shoulder band (option) as shown in Fig. 2-1 (a). The

method shown in Fig. 2-1 (b) is suitable for carrying it for a medium or short distance. Exercise care in protecting the instrument from abnormally large shocks or vibrations when carrying the instrument.

A panel cover as shown in Fig. 2-1 (c) is provided. Attach this cover whenever there is a danger of damaging the front panel during transportation or relocation.

Figure 2-1 Carrying Methods and Panel Cover of SS-4100/SS-4100G



(a)



(b)



(c)

OPERATING POSITIONS

The SS-4100/SS-4100G can be operated in the three different positions as shown in Fig. 2-2. When the instrument is positioned as shown in Fig. 2-2 (c), care must be exercised so that the stand is not turned down, by

pulling hard the probe, for example.

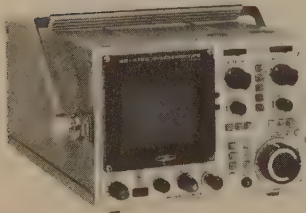
When the operating position is changed, although the vertical position of the trace on the CRT screen may shift slightly, this is not abnormal. The trace will be stabilized in about 1 minute.

Figure 2-2 Appropriate Positioning of CRT Screen

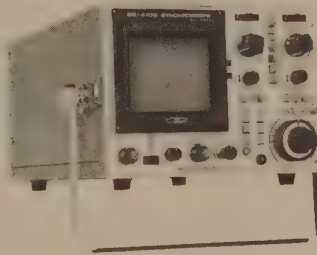
Suitable when the CRT viewing area is located at approximately the same height as the operator's eyes.

When the viewing area is located at a position lower than the operator's eyes.

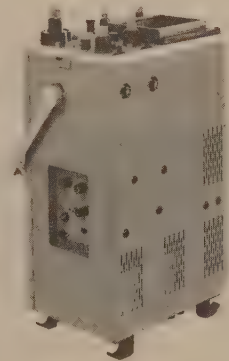
The SS-4100/SS-4100G is placed upright using a stand.



(a)



(b)



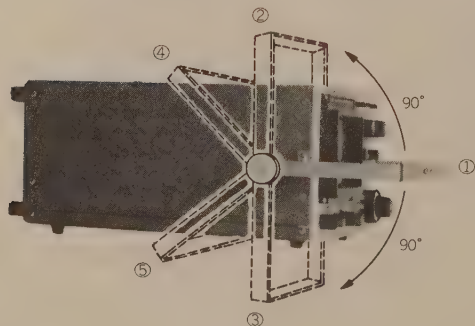
(c)

SETTING THE CARRYING HANDLE

The carrying handle of the SS-4100/SS-4100G can be set at different angles as shown in Fig. 2-3. The handle can be locked in positions (1) through (3). Lock the handle in the required position.

The handle cannot be locked in position (4) or (5). When the SS-4100/SS-4100G is operated in the upright position as shown in Fig. 2-2 (c), if the handle is set in position (2) or (3), the handle might be hit by an object and the synchroscope stand might be turned down. In order to prevent this, the handle should be set in position

Figure 2-3 Setting the Carrying Handle



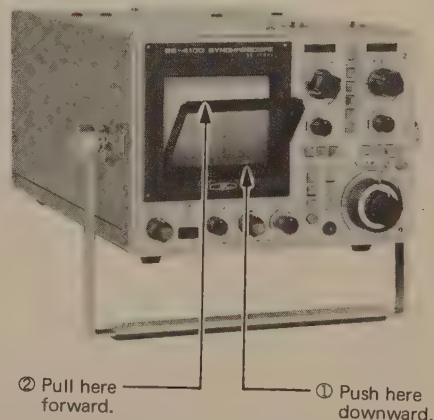
(4) or (5). When the synchroscope is operated in the position shown in Fig. 2-2 (a), the handle should be set in position (4).

To change the handle angle, depress the rotary section from both sides so that the rotary section is unlocked and the handle turns freely.

FILTER, FEATURE AND REMOVAL

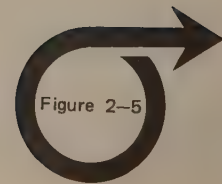
A smoke filter is employed in the SS-4100/SS-4100G, the features of which are as follows:

Figure 2-4 Removal of Filter



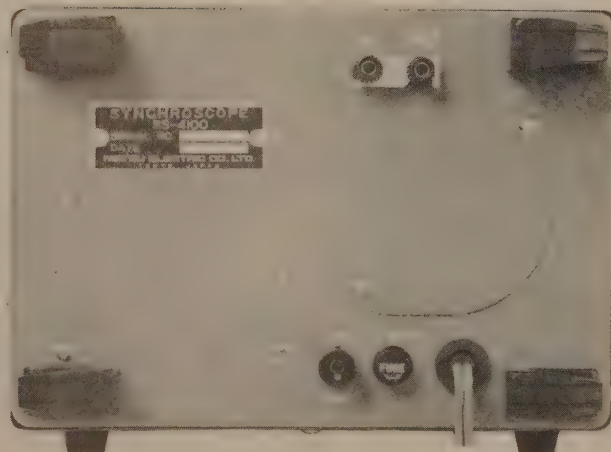
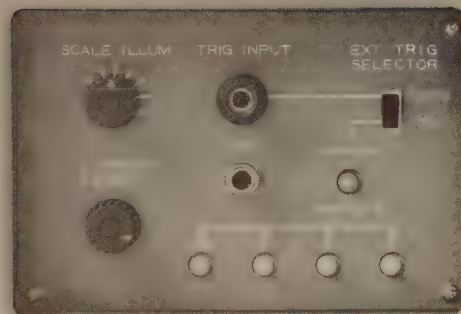
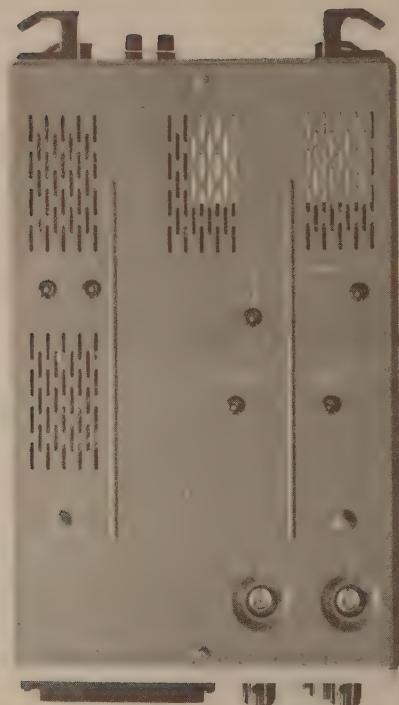
- (1) The filter absorbs external incident light, eliminating reflection from the viewing area.
- (2) The filter surface has minute extrusions and indents, reducing light reflection from the surface.
- (3) The filter promotes the trace contrast and facilitates clear waveform observation.
- (4) The filter abates the intensive light produced by the

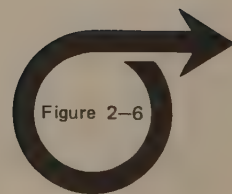
CRT phosphor screen to reduce operator's fatigue. When photographing a display, the filter should be removed to improve definition. The filter can be easily removed by pushing its bottom edge downward and pulling the top edge forward, as shown in Fig. 2-4. The filter is subject to damage and should therefore be handled carefully during removal.

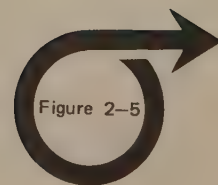




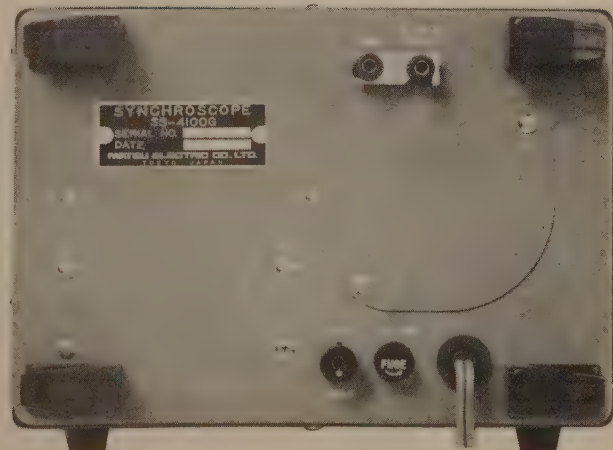
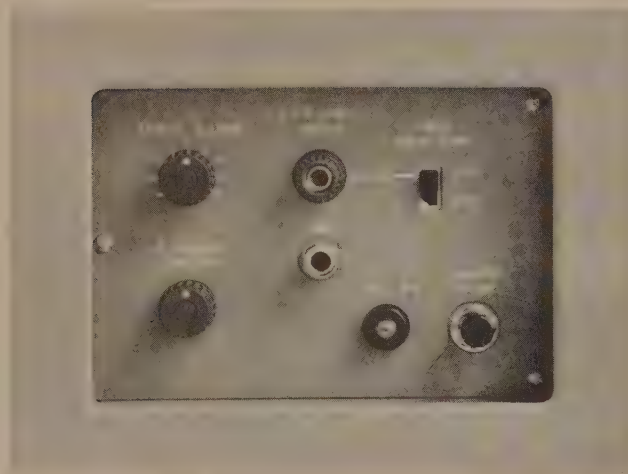












DESCRIPTION OF PANEL CONTROLS

The functions and purposes of switches, controls, and connectors on the front, right, and rear panels will be described. For concentric knobs, the slate grey markings on the panel indicate the slate grey knob positions, and the red markings on the panel indicate red knob positions. Refer to Fig. 2-5 for SS-4100 or to Fig. 2-6 for SS-4100G.

FRONT PANEL

— Power Supply and CRT Circuit —

INTENSITY (Red knob)

Controls brightness of trace or spot. The trace is intensified by clockwise rotation of this control, and de-intensified by counterclockwise rotation.

FOCUS (Slate grey knob)

To focus the trace or spot on the CRT screen.

POWER (PUSH ON)

Main power switch of the synchroscope. When this switch is depressed, the main power is supplied. When it is depressed again, the power is turned off.

— Vertical Deflection System —

Corresponding controls and connectors for CH 1 and

CH 2 function identically. Therefore, these will be described collectively.

MODE

Determines operating mode of dual trace vertical amplifiers. The following modes are available.

CH 1 Selects CH 1 amplifier only. When this button is depressed, the instrument operates as a single trace synchroscope. In the INT trigger mode of operation, triggering is made with the CH 1 signal irrespective of setting of SOURCE selector buttons which will be described later.

CH 2 Selects CH 2 amplifier only. When this button is depressed, the instrument operates as a single trace synchroscope. In the INT trigger mode of operation, triggering is made with the CH 2 signal irrespective of setting of SOURCE selector buttons which will be described later.

ALT Operation of CH 1 and CH 2 is alternately switched after each horizontal sweep. Since signals connected to the two inputs are alternately displayed, simultaneous display of each signal becomes unsuccessful at slow sweep speeds (below approximately 0.2 msec/div). The ALT mode is suitable for observation of comparatively high frequency input signals. Channel selection for INT trigger is made by depressing the INT CH 1 or INT CH 2 SOURCE selector button.

CHOP Signals of CH 1 and CH 2 amplifiers are switched at a repetition rate of approximately 200 kHz and are simultaneously displayed on the CRT screen. In this mode the signals are displayed as dotted lines and signals may become inconvenient to be observed at high sweep speeds

of approximately 50 $\mu\text{sec/div}$ or more. The CHOP mode of operation is preferred for measuring comparatively low frequency signals. Channel selection for INT trigger is made by depressing the INT CH 1 or INT CH 2 SOURCE selector button.

ADD CH 1 and CH 2 amplifiers simultaneously operate, and the mathematic sum or difference of the two input signals is displayed. The sum is displayed when the CH 2 POLARITY knob is in the NORMAL state (pulled state) or the difference is displayed when the knob is in the INVERTED state (pushed state).

CH 2 POLARITY (PUSH INV)

A switch to select output polarity of CH 2. In the normal position a normal output is obtained, and the polarity is inverted as this button is depressed. The polarity returns normal as the button is depressed again.

AC-GND-DC

A switch to select the input coupling mode. In the AC position, the input signal is coupled to the vertical axis amplifier through a coupling capacitor. The DC component of the input signal is blocked and the AC component alone is displayed.

In the DC position the input signal is directly coupled to allow the display of all components, including the DC component of the input signal.

In the GND position the input of the vertical axis amplifier is disconnected from the input connector and grounded to aid in determining the ground potential of the display. (This is normally used to check the reference level for measurement.)

VOLTS/DIV (Slate grey knob)

This switch selects vertical deflection sensitivity from 10 mV/div to 10 V/div in 10 steps. An appropriate position must be chosen for adequate display size. When the switch is set in the CAL 4 DIV position, the input signal is disconnected and the calibration voltage is connected in its place to the vertical axis amplifier. This position is used for GAIN adjustment which will be described later.

VARIABLE (red knob) <SS—4100G only >

A control knob for fine, continuous attenuation of input signal. The attenuation ratio is largest (1/2.5 or over) when the knob is turned to the extremely counterclockwise position. Thus, the knob can cover continuously the gap between two adjoining ranges of the VOLTS/DIV switch. For quantitative measurement of the input signal, this knob should be set in the CALIB position.

UNCALIB CH 1 or 2 <SS—4100G only >

This lamp indicates the uncalibrated state of CH 1 and CH 2 in common. This lamp turns on when either one or both of CH 1 and CH 2 VARIABLE knobs are not in the CALIB position(s) and, thus, alert the operator to that the displayed amplitude must not be read as a calibrated value with respect to the indication of the VOLTS/DIV switch.

POSITION

A control to adjust the vertical position of the trace or spot. When this control is turned clockwise, the trace moves upward, and it moves downward with counterclockwise rotation.



These lamps indicate that the trace or spot has been deflected off the CRT screen upward or downward. The trace or spot can be brought back onto the viewing area by means of the POSITION control.

— Horizontal Deflection System —

SOURCE

These switches select trigger signal sources. (For details, refer to OPERATING PROCEDURE, PROPER TRIGGERING at a later part of this instruction manual.)

INT CH 1 Sweep is internally triggered by the input signal fed to CH 1 INPUT connector.

INT CH 2 Sweep is internally triggered by the input signal fed to CH 2 INPUT connector.

EXT For the SS-4100, sweep is externally triggered by a signal fed through the TRIG INPUT connector or AND GATE connector as selected by the EXT TRIG SELECTOR which will be described later.

For the SS-4100G, sweep is either externally triggered by a signal applied through the TRIG INPUT connector or internally triggered with the LINE signal applied within the synchroscope.

COUPLING

These switches select appropriate coupling modes for stable triggering. (For details, refer to OPERATING PROCEDURE, PROPER COUPLING at a later part of this

instruction manual.)

AC The trigger signal is AC coupled. Since the DC component of the trigger signal is blocked, influence of the DC component of the trigger signal is eliminated.

HF REJ This coupling mode is suitable for observation of two signals in the CHOP mode of operation and for observation of signals which include high frequency noises. Triggering can be easily made with the vertical synchronization signal of a television receiver set.

DC EXT ONLY The external trigger signal is coupled directly to the trigger circuit and the sweep can be triggered by DC. In the INT triggering mode of operation, the coupling mode is automatically switched to the AC coupling.

SWEEP MODE

These switches select following sweep modes.

FULL AUTO The sweep circuit is triggered in the FULL AUTO mode. Triggering is made for the full range of LEVEL control, irrespective of trigger signal voltage. However, when the trigger signal is below 100 Hz or no trigger signal is applied, the sweep runs in the free run mode. The triggerable frequency range is 100 Hz to 10 MHz.

AUTO The sweep circuit is triggered in the AUTO mode. When the trigger signal is below 50 Hz or the LEVEL has exceeded the triggering point (at which point of the input signal waveform the triggering operation starts), the sweep runs in the free run mode. The triggerable frequency range is 50 Hz to 10 MHz.

NORM The sweep circuit is triggered in the NORMAL mode. When the trigger signal is below 50 Hz or when the LEVEL has exceeded the triggering point (at which point of the input signal waveform the triggering operation starts), the sweep does not run and a spot is displayed on the CRT screen. The triggerable frequency range is DC to 10 MHz.

SINGLE <SS-4100G only> The trace is swept only for once when the trigger signal is applied. The single-sweep operation is possible when the HORIZ DISPLAY is set in the A, A INT BY B or DLY'D (B) position.

RESET <SS-4100G only>

This pushbutton switch has an internal lamp to indicate the operated state of the switch. The switch has a function to reset the circuit to the READY state for single-sweep operation (the state ready to drive the sweep only for once upon receipt of the trigger signal).

The lamp has a function to indicate (when lighted) that the circuit is in the READY state.

(PUSH + SLOPE) LEVEL
(PULL - SLOPE)

This control is a combination of a potentiometer and a switch (push and pull). The potentiometer is for triggering level control. The switch is for triggering slope selection. When it is pushed, the waveform displayed on the CRT screen is triggered by a positive-going slope of the trigger signal. When it is pulled, the waveform is triggered by a negative-going slope.

HORIZ DISPLAY

These switches select sweep modes as follows:

A This sweep mode is used for conventional waveform measurement. Horizontal trace is produced by the A sawtooth wave generator. Sweep time is determined by the A TIME/DIV selector.

A INT BY B For delayed sweep mode for magnification of a certain section of the input signal waveform. (For details, refer to OPERATING PROCEDURE, DELAYED SWEEP OPERATION in a later part of this instruction manual.)

DLY'D (B) For magnification of the section selected by sweep delay operation. (For details, refer to OPERATION PROCEDURE, DELAYED SWEEP OPERATION.)

B MODE (PUSH TRIG)

This switch selects either continuous delay mode or triggered delay mode. The pushed position is for the non-triggered delay mode and the pulled state is for the triggered delay mode.

A, B TIME/DIV AND DELAY TIME (Outer slate grey knob and inner slate grey knob)

The outer knob selects the A TIME/DIV and DELAY TIME, and the inner knob selects the B TIME/DIV. The A TIME/DIV (DELAY TIME) control is used to select a sweep time from 0.5 μ sec/div to 0.5 sec/div in 19 steps. An optimum position for observation should be determined in accordance with the frequency and rise time (or fall time) of the input signal. This control also determines the delay

time in the delayed sweep operation.

The B TIME/DIV control is used to select a sweep time in the delayed mode of operation from 0.5 μ sec/div to 0.5 sec/div in 19 steps. The sweep time and delay time are directly indicated by the setting of the TIME/DIV control knobs.

A VARIABLE (red knob) < SS-4100G only >

Fine control of the A sweep time. Each range value of the A TIME/DIV switch is continuously varied up to a factor of 1/2.5 (or over). The sweep time becomes slower as the knob is turned counterclockwise. For quantitative measurement, the knob must be set in the CALIB position.

A UNCALIB < SS-4100G only >

This lamp turns on to indicate, when the A VARIABLE knob is in other position than CALIB, that the displayed value is not calibrated with respect to the value indicated by the TIME/DIV switch.

DELAY TIME

This control continuously adjusts the delay time to display the magnified section of the input signal waveform on the CRT screen. A single knob is used for both coarse and fine adjustments. (For details, refer to OPERATING PROCEDURE, SWEEP DELAY OPERATION.)

SWEEP STOP < Located on the right side panel for SS-4100G >

Pushbutton to stop the sweep operation. For the SS-4100, the button is linked with the SWEEP MODE

selector. When the button is pressed, the sweep stops and the electron beam is displayed as a stationary spot on the CRT screen. If a certain button of the SWEEP MODE selector is pressed under the above state, the SWEEP STOP state is released and the electron beam starts sweeping at the corresponding frequency.

For the SS-4100G, the button is located on the right side panel. The sweep operation is stopped during the period the button is kept depressed. When the button is released, the SWEEP STOP state terminates and the sweep operation resumes.

POSITION $\leftrightarrow$ (Slate grey knob)

This control determines the horizontal position of the trace or spot. As the knob is turned clockwise, the trace or spot moves rightward; as it is turned counterclockwise, the trace or spot moves leftward.

(PULL x 10 MAG) FINE (Red knob)

This control is a combination of a potentiometer and a switch (push and pull). The potentiometer is a fine position control. When the switch is pulled, the sweep time is magnified by a factor of 10. The fine control function is effective for both pushed and pulled states of the switch, although it is more effective in the pulled state (magnified sweep state).

— Calibration Signal —

CAL 4 V < Located on the right side panel for SS-4100G >

This connector supplies a calibration signal of 4 V, 1 kHz for calibration of the probe.

TOP PANEL

INPUT CH 1 CH 2

These BNC-type connectors are for connection of input signals or probe.

GAIN CH 1 CH 2

These semi-fixed resistors are for sensitivity calibration. They must be so adjusted that an amplitude of 4 divisions is obtained on the CRT screen when the VOLTS/DIV switch is set in the CAL 4 DIV position.

CH1 POSITION ADJ < SS-4100 only >

Semi-fixed resistor for balancing of CH 1. This control must be so adjusted that the trace is positioned in the vertical center position of the graticule when the POSITION control is set in its center position.

CH2 POLARITY BAL < SS-4100 only >

Semi-fixed resistor for balancing of CH 2. This control must be so adjusted that the trace is not shifted when the CH 2 POLARITY (PUSH INV) pushbutton switch is pressed.

DC BAL CH 1 CH 2 < SS-4100G only >

Semi-fixed resistor for DC balancing of vertical deflection system. It must be so adjusted that the trace does not vertically move when the VARIABLE knob is turned.

ASTIG

This semi-fixed resistor is an astigmatism control which is used to obtain sharp focussing of the trace on CRT screen when such is unattainable with the FOCUS control alone.

TRACE ROTATION

This semi-fixed resistor is used to align the trace with the graticule.

RIGHT SIDE PANEL

SCALE ILLUM

For illumination adjustment of graticule. Illumination is brightened as this control is turned clockwise, and it is darkened as the control is turned counterclockwise.

A SWEEP LENGTH

For adjustment of the A sweep length. The sweep length is continuously variable for a range of approximately 3.5 div to 11 div. The sweep is shortened as this control is turned counterclockwise.

EXT TRIG SELECTOR < SS-4100 only >

Selects external trigger mode as follows:

NORM Triggering is made with the input signal itself or by an external signal which has a certain periodical relationship with respect to the input signal. The external trigger signal must be applied through the TRIG INPUT connector.

LOGIC Triggering is made in an AND logic mode by external signals applied to the AND GATE connectors. (For details, refer to OPERATING PROCEDURE, AND GATE OPERATION.)

TRIG SELECTOR <SS-4100G only>

For selection of EXT or LINE trigger as below.

EXT For external triggering. The sweep is triggered by externally applying the measured input signal itself or other external signal (which has a certain periodical correlation with respect to the measured input signal) through the EXT TRIG INPUT connector.

LINE For triggering with the AC power line frequency. The power line voltage (conditioned to the required voltage) is applied to the trigger generator.

TRIG INPUT <for SS-4100>

EXT TRIG INPUT <for SS-4100G>

An external trigger signal for external triggering mode of operation is applied to this connector.

AND GATE <SS-4100 only>

External signals for AND logic mode of operation are applied to these connectors. Maximum four external signals can be simultaneously applied.

MONITOR <SS-4100 only>

This terminal is used to monitor the time relationship

among a plural number of signals applied to AND GATE connectors.

GND

Ground terminal.

REAR PANEL

Z AXIS INPUT, GND

These are for intensity modulation with an external signal. For intensity modulation, disconnect the jumper bar, connect the external intensity modulation signal to the Z AXIS INPUT connector, and connect the signal ground to the GND terminal. In the normal mode of operation (without intensity modulation), the Z AXIS INPUT connector and GND terminal must be connected together with the jumper bar.

POWER CORD

To feed the AC line power to the synchroscope.

1 A SLOW

A slow-blow fuse of 1 A rating is placed in this fuse holder. (When the synchroscope is operated on an AC line of 200 V or 230 V, a slow blow fuse of 0.5 A rating must be used.)

LINE VOLTAGE SELECTOR (100 V – 115 V)

This switch must be set in accordance with the line voltage on which the synchroscope is operated.

OPERATING PROCEDURE

The proper operating procedures for the SS-4100/SS-4100G synchroscope will be described in this section. The best way to become familiar with the operation of this instrument is to apply various input signals and operate the controls.

The internal circuits will not be damaged by manipulation of the panel controls and switches. However, the precautions described in the following paragraphs "PRE-START OPERATION" must be observed.

PRE-START OPERATION

Check the Line Voltage

The SS-4100/SS-4100G has been designed for operation on a wide range of line voltage (six voltage ranges) as shown in Table 2-1, through switch selection.

Table 2-1. Line voltage ranges

Nominal voltage	Voltage range	Remarks
100 V AC 115 V AC	90 - 110 V 106 - 128 V	Standard; 100 V - 115 V switch selection
110 V AC 200 V AC 220 V AC 230 V AC	99 - 121 V 180 - 220 V 198 - 242 V 211 - 257 V	Option; 100 V - 110 V (Notes) 110 V - 115 V 200 V - 220 V 200 V - 230 V 220 V - 230 V

Notes: Line voltage change is optional. When voltages other than the standard is required, the above voltage are possible through internal wiring modification and switch selection.

Set the LINE VOLTAGE switch on the rear panel in the correct position corresponding to the line voltage on which the synchroscope is to be operated. Note that the synchroscope may be damaged if it is operated on a source voltage other than listed in the table. Although the tabulated voltage cover almost all line voltages used throughout the world, if the line voltage in your particular area is not within these ranges, boost or reduce the line voltage into one of these specified ranges using an appropriate voltage booster.

Ambient Temperature

The ambient temperature range for normal operation of the SS-4100/SS-4100G is from -10°C to +50°C. Avoid using this instrument in conditions exceeding this range.

Do Not Apply Abnormally Large Input Signals

The maximum allowable input voltages of the connectors and terminals are as shown below. Do not apply voltages higher than these values.

Signal input connectors: 600 V (DC + AC peak)
Probe tip: 600 V (DC + AC peak)
Z AXIS INPUT: 100 V (DC + AC peak)

Do Not Leave an Intensified Spot Stationary for Long Periods

Excessive intensity of a spot or trace, especially when left in one place for a long period, may damage the CRT phosphor screen or other related circuit components.

APPLYING THE POWER AND OBTAINING THE SWEEP

When the PRE-START OPERATION is complete, you are ready to proceed with actual operation. The basic operating procedure for applying the power, triggering the sweep, and displaying a waveform will be described below.

Turning on the Power and Producing the Spot

Set the power switch initially in the OFF state and connect the power cable plug to the line outlet. Place the following controls in the positions indicated below:

INTENSITY	Fully clockwise
MODE	CH 1
AC-GND-DC	GND
POSITION (vertical)	Center of range
HORIZ DISPLAY	A
SOURCE	INT CH 1
SWEEP MODE	AUTO
SWEEP STOP	Push (on)
POSITION (horizontal)	Center or range
(PULL x 10 MAG) FINE	Push, center of range

Turn on the POWER switch. The instrument becomes operational approximately 15 seconds after it is turned on. Slowly turn clockwise the INTENSITY control until a spot appears on the CRT screen.

Focussing the Spot

Move the spot to the center of the CRT screen (viewing area) by means of the vertical and horizontal POSITION controls. Adjust the FOCUS control so that a sharp image

is obtained. (When the spot is swept by applying a signal, the trace image may not be sharply focussed with the FOCUS control alone. In such a case, adjust also the ASTIG control. For details, refer to PREPARATIVE PROCEDURE of SECTION 3.)

Sweeping the Trace

Depress (turn off) the SWEEP STOP button. When this is done, the sweep should start running. The sweep may become somewhat unstable at the midposition of the LEVEL control. This is not abnormal and the sweep will be stabilized by turning the control slightly to the right or left.

With the controls set as instructed above, the trace starts from the center of CRT screen and sweeps to the right. Turn the horizontal POSITION control counterclockwise to move the sweep start point to the left end of the graticule. Turn the A TIME/DIV switch to ensure that the sweep time varies correspondingly.

Displaying a Waveform

The next step is a practice operation to display a waveform, using the calibration voltage (CAL) as an input signal. When the VOLTS/CM selector is set in the CAL 4 DIV position, the calibration voltage is internally connected to the vertical circuit and a waveform with an amplitude of 4 divisions should be displayed on the CRT screen. However, for the purpose of practice, connect the CAL 4 V output connector to the CH 1 input connector using BNC connection lead wire D which accompanies the synchroscope as an accessory item. (See Fig. 2-7.)

Set the controls as follows:

VOLTS/DIV (CH 1) 1 V
 VARIABLE (CH 1) CALIB
 <SS-4100G only>
 AC-GND-DC (CH 1) DC
 A TIME/DIV 0.2 msec.

When the above setting is made, a square wave with vertical amplitude of 4 div should be displayed on the screen. Next, turn counterclockwise the VOLTS/DIV switch through its steps. The vertical amplitude should decrease in accordance with the steps.

For the SS-4100G, also turn counterclockwise the VARIABLE knob to confirm that the amplitude is continuously attenuated in response. After the confirmation, return the VARIABLE knob to the CALIB position and turn the VOLTS/DIV switch to the 1 V range position so that the vertical amplitude becomes 4 div. The above operation will clearly indicate to you the relationship among the input signal, VOLTS/DIV switch and VARI-

ABLE knob.

Since the above signals are displayed in the free-run mode, the horizontal display is not stable and may be difficult to be observed. When the A TIME/DIV switch is set at a high sweep speed to magnify a part of the display, the display will become a number of horizontal lines. This can be avoided by properly triggering the sweep.

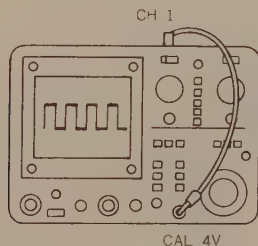
Before Triggering

Proper triggering is a key point in operating a synchroscope. In general the following items must be determined prior to triggering the sweep.

(1) Selection of trigger mode:

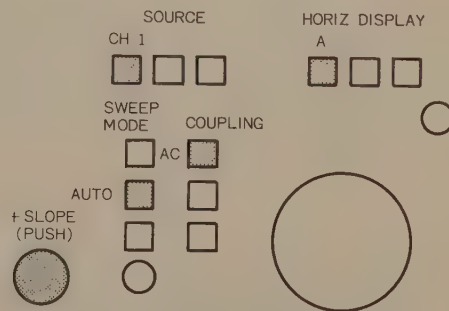
Select either internal trigger (INT) or external trigger mode. For internal trigger, select either CH 1 or CH 2 signal to be used as the triggering signal.

Figure 2-7 Feeding the CAL Signal to CH 1 INPUT



For the SS-4100G, the CAL 4V terminal is located on the right side panel.

Figure 2-8 Setting of Control Switches

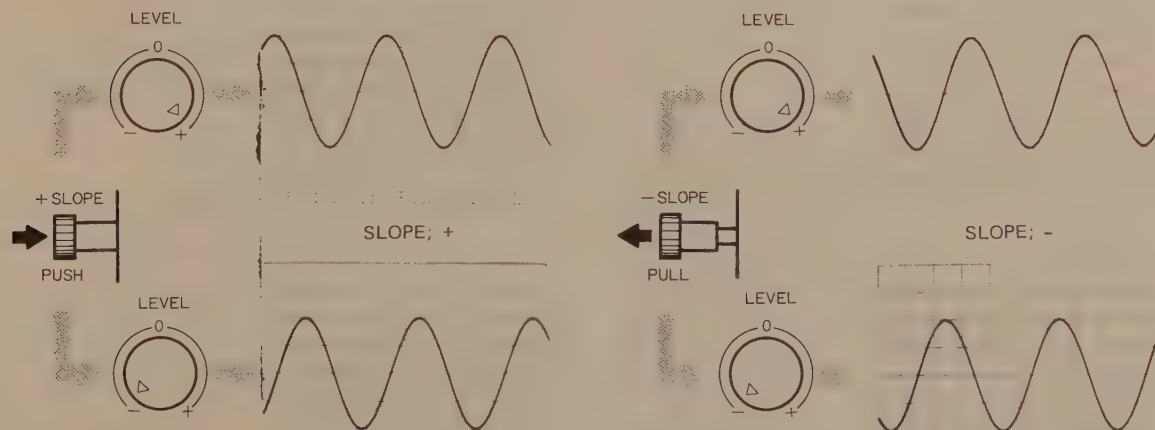


- (2) Selection of coupling mode:
Determine the coupling mode of the trigger signal to the trigger circuit either on AC coupling, HF REJ coupling, or DC coupling (for external trigger only).
- (3) Selection of trigger slope:
Determine whether triggering is made with a positive-

going or negative-going slope of the trigger signal.

In this practice operation, the sweep will be triggered in the AC coupling, internal trigger (INT) mode, and triggering will be made by a positive-going slope of the trigger signal. Therefore, the trigger controls must be set as follows: (See Fig. 2-8.)

Figure 2-9 Effects of SLOPE and LEVEL on Display



SOURCE	INT CH 1
COUPLING	AC
SLOPE	+
SWEEP MODE	AUTO
HORIZ DISPLAY	A

Triggering Method (1) (Auto Trigger)

The preceding control settings enable triggering by only adjusting the LEVEL control. Turn slowly the LEVEL control. The display should be stably triggered at approximately mid-position of the control. Vary the SLOPE switch and adjust the LEVEL control as shown in Fig. 2-9.

Of the SS-4100/SS-4100G, the SLOPE switch and LEVEL control potentiometer can be manipulated with the same knob. The LEVEL control action remains the same irrespective of the SLOPE switch setting (pushed state for triggering by positive-going slope or pulled state for triggering by negative-going slope). The above operation will demonstrate to you the effects of the SLOPE switch and LEVEL control on the displayed waveform.

Fig. 2-9 shows an example of a sine wave displays but the triggering point can be selected in the same manner as for a square wave. A high sweep speed which provides a magnified display of the leading or trailing edge will aid in the observation of the trigger point.

Of the SS-4100/SS-4100G, the variable range of the trigger point is from 10% to 90% of the slope height. (This is for internal triggering with a sine wave trigger signal of approximately 1 kHz with a vertical amplitude of 6 div on the graticule. The triggering range in the external trigger mode differs according to the external trigger signal level.)

Turn the VOLTS/DIV switch of CH 1 to the 10 V position to display the waveform with a vertical amplitude

of 0.4 div. Since the trigger signal is reduced in accordance with reduction of the vertical amplitude of the displayed signal, triggering may become ineffective and the sweep may run in the free-run mode, depending upon the setting of the LEVEL control. Adjust the LEVEL control so that the triggering is properly effected and the waveform is stably displayed.

In the AUTO trigger mode, the display will free-run when no triggering signal is present or when the LEVEL control position exceeds the triggering point. Therefore, the AUTO position is advantageous when a free-running sweep is desirable, or for example, when the ground potential is to be confirmed. Note, however, that the display will not be triggered in the AUTO mode by an input signal lower than 50 Hz. When the trigger signal is lower than 50 Hz, the triggering should be made in the NORM mode which will be described subsequently.

Triggering Method (2) (Normal Trigger)

Push the NORM button of SWEEP MODE switch. As in the case of the AUTO trigger mode, the sweep is triggered by adjusting the LEVEL control.

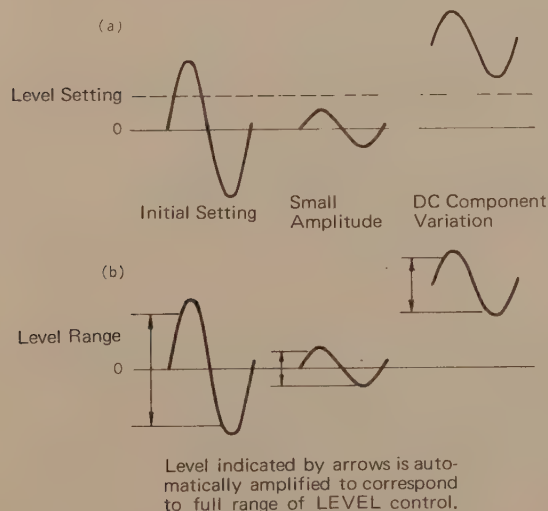
In this trigger mode, however, when there is no trigger signal or the LEVEL control setting has exceeded the triggering point, the sweep stops and the beam is stationary or is in a standby state. (No spot is produced on the CRT screen even when the INTENSITY control is turned to the fully clockwise position.)

Triggering Method (3) (Full Auto Trigger)

In the preceding methods (1) and (2), even if the LEVEL control has initially been properly adjusted and the sweep has been correctly triggered, the triggering operation may

be disturbed (sweep may be synchronized) or the starting point of sweep may be varied if the signal amplitude is reduced or the DC component of the signal is varied in the DC-coupled external trigger mode. Furthermore, if the trigger signal voltage is small, the triggerable range is small and adjustment of the LEVEL control is somewhat critical.

Figure 2-10 Triggerable Range in FULL AUTO Mode



In the FULL AUTO mode of triggering operation, triggering can be successfully made for the full range of the LEVEL control irrespective of the amplitude of the trigger signal. When the FULL AUTO button of SWEEP MODE switch is pushed, a relationship between signal amplitude and LEVEL control as shown in Fig. 2-10 (b) is obtained. Even when the trigger signal amplitude is small, it is amplified so that triggering can be effectively made for the full adjustable range of the LEVEL control and the function of the LEVEL control is simply to determine the triggering point on the trigger signal waveform. This can be well demonstrated by turning for trial the LEVEL control.

Precautions in Manipulating the Pushbutton Switch

The SS-4100/SS-4100G amply employs push-button switches. Three push-button switches of a 2-step type (such a type that the switch is turned on or off each time the switch is pushed) are used for the POWER, CH 2 POLARITY and B MODE, switches. Five push-button switches of 3-step or more gang type (such a type that switches are ganged and setting is made for the pushed one of the switches) are used for the MODE, SOURCE, COUPLING, SWEEP MODE, and HORIZ DISPLAY switches. Precautions here shall be mentioned on the latter type of switches.

- (1) It is not impossible to push simultaneously two or three buttons of the ganged switches. However, such may shorten the life of the switches. One button must be securely depressed each time.
- (2) A rotary switch or a lever switch is always set in a

certain position. Different from these switches, ganged push-button switches could be left in a state that none of the buttons has been depressed. For the

For the SS-4100/SS-4100G, in order to avoid such an astray state, an automatic feature is incorporated so that the gang switches are automatically set for buttons as follows:

MODE	CH 1
SOURCE	INT CH 1

COUPLING	AC
SWEEP MODE	AUTO
HORIZ DISPLAY	A

When the DC EXT ONLY button of COUPLING selector is depressed, the DC coupling is realized only in the external trigger mode of operation. In the internal trigger mode of operation (when INT CH 1 or INT CH 2 button of SOURCE selector is depressed), the coupling is automatically set in the AC coupling mode.

PROPER TRIGGERING ?

SOURCE

For stable display of input signal waveforms, the sweep circuit must be triggered by the input signal or an external signal which has a certain time relationship (an integer multiple) with respect to the input signal. This signal which controls the sweep repetition is called trigger signal.

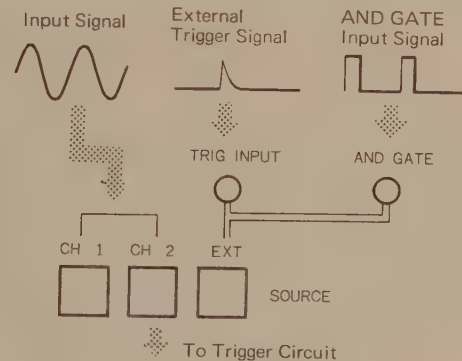
In the internal trigger mode of operation, the INT button of SOURCE selector is depressed and a part of the input signal from the vertical amplifier circuit is fed to the trigger circuit. (See Fig. 2-11.)

The triggering method in which the SOURCE switch is set in the EXT position (and the TRIG SELECTOR also is set in the EXT position for the SS-4100G) and the sweep is triggered by externally applying the measured signal itself or other signal which has a certain periodical correlation with respect to the measured signal is called "internal trigger." The other triggering method in which the SOURCE switch is set in the EXT position and the sweep is triggered by the AC line frequency (through the internal power transformer of the synchroscope) is called "line trigger." (The line trigger is possible for the SS-4100G only.)

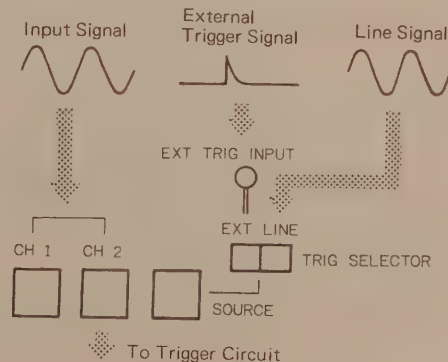
Internal Trigger For the internal trigger mode, the trigger signal is internally obtained from the vertical deflection amplifier. Even an input signal of very low amplitude is internally amplified to an adequate level for triggering. Therefore, panel control operation for this mode is very simple, and also the chance that the comparatively low input impedance of the external trigger circuit may load the trigger signal source is eliminated. Due to these advantages, the internal trigger mode is generally convenient for measurement.

For the internal trigger mode, the sweep can be triggered

Figure 2-11 Selection of Trigger Signal with SOURCE Switch—



(a) For the SS-4100



(b) For the SS-4100G

PROPER TRIGGERING

either by CH 1 input or CH 2 input by pressing the corresponding button of the SOURCE selector. To measure two signals of the same frequency, the one which has a higher voltage and a lower noise may be selected as the trigger signal by means of the SOURCE selector to obtain more stable triggering.

To measure two input signals of different frequencies (but with an integer ratio between the two frequencies) as shown in Fig. 2-12 for example, the one with the lower frequency must be selected as the trigger signal. If the other one (higher frequency) is selected as the trigger signal, the input signal of the lower frequency cannot be properly displayed. In the example shown in Fig. 2-12, a sawtooth signal must be used as the trigger signal; if a pulse signal is used, the sawtooth input signal cannot be properly displayed.

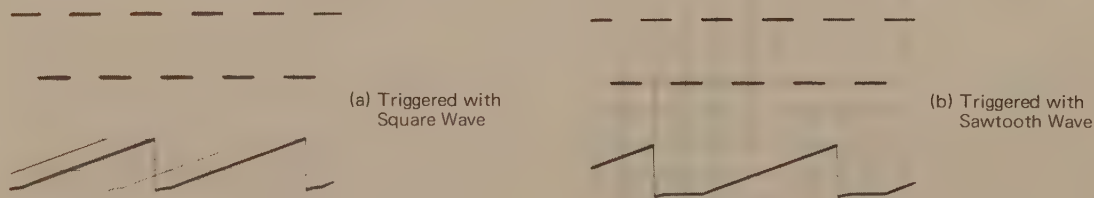
played.

For phase difference measurement of two signals, the one with the leading phase must be selected as the trigger signal.

External Trigger The advantages of the internal trigger are inversely reflected as the disadvantages of the internal trigger. However, the external trigger provides the following advantages.

First, the triggering circuit is not affected by the vertical deflection system. For example, the voltage level of the signal, which is fed to the trigger circuit in the internal trigger mode, varies when the position of the VOLTS/DIV switch is changed or the POSITION control is turned.

Figure 2-12 Triggering of two Different Frequency Signal



PROPER TRIGGERING

These variations may necessitate readjustment of the LEVEL control every time the position of the VOLTS/DIV switch is changed. Conversely, in the external trigger mode, the triggering is stable, once adjusted, regardless of variation in the vertical deflection system, except in the cases where the external trigger signal also varies.

Second, when it is desired to start the sweep a certain period in advance or after a certain time delay to display a particular point on the waveform, and provided that an appropriate triggering signal (which is applied through the TRIG INPUT connector) is available, the external triggering mode facilitates stable observation of the particular point.

For external triggering for the SS-4100G, both SOURCE SELECTOR and TRIG SELECTOR (located on the right side panel) must be set in the EXT state.

For external triggering of the SS-4100G, either the NORM trigger in which the sweep is triggered with the external signal applied through the TRIG INPUT terminal or the LOGIC trigger in which the sweep is triggered with the signal applied through the AND GATE terminal is selectable by means of the EXT TRIG SELECTOR which is located on the right side panel. (For the LOGIC trigger, refer to "AND GATE OPERATION" which will be described later.)

Conversion tips to use a BNC input connector as the TRIG INPUT terminal for SS-4100 or the EXT TRIG INPUT terminal for SS-4100G are available from IWATSU. Refer to Section "OPTIONAL ACCESSORIES" at the end of this instruction manual.

Line Trigger <SS-4100G only> The line trigger is advantageous in that it is not affected by the vertical deflection system as is the case when the line frequency

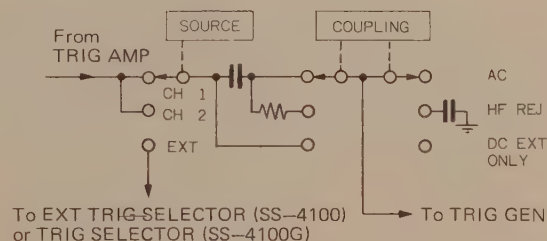
trigger signal is employed and it can stably display harmonic signals of the line frequency.

COUPLING

The COUPLING selector selects feeding mode of the trigger signal into the trigger circuit. Three coupling modes of AC, HF REJ, and DC are selectable with respective push-buttons. (The DC mode is for external triggering only.) The trigger signal is coupled to the trigger circuit through a capacitor (AC), a low pass filter (HF REJ), or directly (DC) as shown in Fig. 2-13.

A suitable coupling must be used in accordance with the type of trigger signal (DC, AC, AC superimposed on DC, or signal including high frequency noise component).

Figure 2-13 Coupling Modes of Trigger Signal



PROPER TRIGGERING

AC The trigger signal is fed to the trigger circuit through a coupling capacitor as shown in Fig. 2-13. The DC component of the trigger signal is blocked by the capacitor and the AC component alone is effectively used for triggering, ensuring a stable trigger operation irrespective of the DC component. This coupling is convenient for conventional measuring purposes. However, triggering will become unstable at frequencies below 30 Hz.

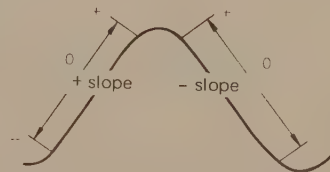
HF REJ The trigger signal is coupled to the trigger circuit through a low pass filter as shown in Fig. 2-13. The filter blocks the high frequency component (higher than approximately 10 kHz) and passes the low frequency component alone to the trigger circuit. This coupling mode can be advantageously used when the trigger signal contains a high frequency noise component. It also can be conveniently used for triggering with the vertical synchronization signal of a television receiver set.

DC EXT ONLY As shown in Fig. 2-13, the trigger signal is directly connected to the trigger circuit, enabling triggering from a varying DC signal. However, if the trigger signal is superimposed on a DC component which is out of the controllable range of the LEVEL control, triggering cannot be made with such a signal. When an INT button of SOURCE selector is depressed, coupling is not made in the DC mode but is automatically switched to the AC mode.

SLOPE

When the SLOPE switch (LEVEL control) is pushed in, triggering is effected by the positive-going slope of the trigger signal. When it is pulled out, triggering is effected by the negative-going slope. These are illustrated in Fig. 2-14. Selection of slope is not critical for observation of a sinusoidal wave or a square wave. However, if the measured signal is a narrow pulse wave, the leading edge of the pulse wave cannot be correctly displayed unless the SLOPE switch is correctly set in conformity with the polarity of the observed signal.

Figure 2-14 Slope Selection



DUAL TRACE OPERATION AND MEASUREMENT OF SUM OR DIFFERENCE OF TWO SIGNALS

Dual Trace Operation in ALT Mode

Push the ALT button of MODE selector. Two traces of CH 1 and CH 2 should appear on the CRT screen. Next, set the VOLTS/DIV switches of both CH 1 and CH 2 in the 2 V positions. Set the AC-GND-DC switches in the AC or DC state. Connect the CAL 4 V connector to both CH 1 and CH 2 INPUT connectors using the BNC cable D (supplied) as shown in Fig. 2-15. When this is done, two traces should be displayed on the CRT screen as shown in Fig. 2-15.

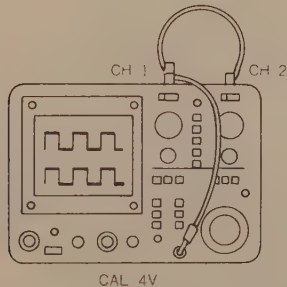
Next, turn counterclockwise the A TIME/DIV switch to

reduce the sweep speed. In the ALT mode of operation, sweep is alternately effected between CH 1 and CH 2 as shown by the arrows in Fig. 2-16, and therefore, simultaneous observation of two traces on the CRT screen becomes impossible at lower sweep speeds. For observation of signals of such low frequencies that the A TIME/DIV switch is required to be set in the 2 msec or slower sweep speed positions, the CHOP mode should be employed as will be explained subsequently.

Dual Trace Operation in CHOP Mode

Two traces can be displayed even at slow sweep speeds. Conversely with the case of the ALT mode, if the sweep speed is increased (when the A TIME/DIV switch is set in

Figure 2-15 Setup for Dual Trace Display



For the SS-4100G, the CAL 4V terminal is located on the right side panel.

Figure 2-16 ALT Mode Display



the 50 μsec or higher positions), the traces may be displayed as series of dotted lines. Since traces are switched between CH 1 and CH 2 at a frequency of approximately 200 kHz as shown in Fig. 2-17, such high frequency signals or fast rise (fall) time signals that the A TIME/DIV switch is required to be set in the 50 μsec or faster positions cannot be successfully displayed. Such fast-changing signals must be displayed in the ALT mode.

For display of two signals of different frequencies (but with a certain integer periodical time relationship between the two signals), select the proper internal trigger channel. For proper selection, refer to PROPER TRIGGERING.

In displaying two signals in the CHOP mode, still more stable waveform can be displayed by pushing the HF REJ button of COUPLING selector.

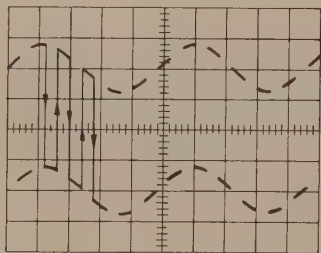
Measurement of Sum or Difference of Two Signals

To measure the sum of the signals of CH 1 and CH 2, set the CH 2 POLARITY switch in the normal state and push the ADD button of MODE selector in addition to the procedure described in the preceding paragraphs.

To measure the difference between the two signals, push the CH 2 POLARITY button. When this is done, the polarity of the CH 2 signal is inverted and then is added to the CH 1 signal, or an amplitude of "CH 1 + (-CH 2)" is displayed on the CRT screen. When the two signal amplitudes are identical and both VOLTS/DIV switches are set in the same position, a single line trace should appear on the CRT screen.

In the ADD mode of operation, the displayed trace is vertically adjustable by the POSITION control of either CH 1 or CH 2. For correct measurement, it is recommendable to set both POSITION controls in their mid-positions.

Figure 2-17 CHOP Mode of Display Operation



SWEEP MAGNIFICATION

It is possible to magnify, with regard to time, a desired particular part of the input signal by increasing the sweep speed. However, sweep magnification in this method may drive the desired part out of the viewing area unless the part is very close to the starting point of the sweep. By pulling the (PULL $\times 10$ MAG) FINE switch, the center portion of the display is magnified by 10 times as shown in Fig. 2-18. Although only 10-div section of the waveform is displayed on the viewing area, the trace actually has been expanded to 100 div. The entire trace can be observed by rotating the POSITION and FINE controls.

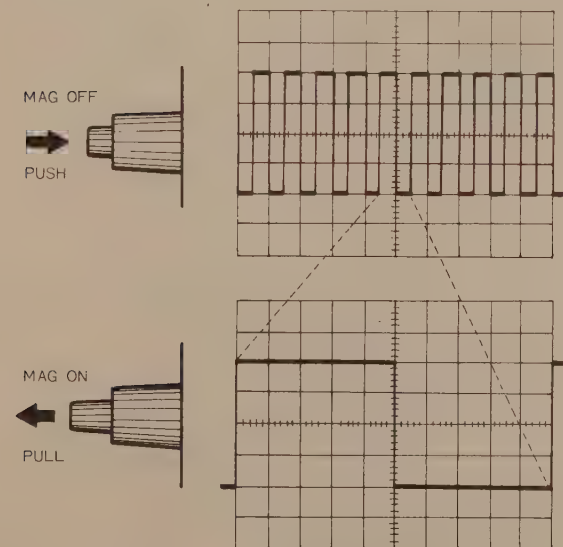
The sweep time, when magnified, is 1/10 of the switch position indication. The maximum sweep speed of 500 nsec/div for an unmagnified trace becomes 500 nsec/div $\times$

$1/10 = 50 \text{ nsec/div.}$

Magnification of the sweep is advantageous to increase the maximum sweep speed, but it reduces trace intensity and may cause confusion in calculating the time relation of the displayed waveform (multiplication by a factor of $1/10$ might be overlooked). It may be advisable not to use

the magnified sweep except when magnifying a particular section of the waveform which is a considerable distance from the starting point of the sweep.

Figure 2-18 Sweep Magnification with MAG Switch



DELAYED SWEEP OPERATION

Although sweep magnification with the MAG switch is simple to operate and magnifies the nominal TIME/DIV by exactly 10, its magnification is fixed at 10 times. On the other hand, magnification of the display by the delayed sweep can extend the magnification factor as determined by the A sweep time and B sweep time. This magnification factor, however, is limited by the frequency of the given input signal. That is, when the frequency of the input signal is high and the A TIME/DIV switch is set in the $0.5 \mu\text{sec}$ position prior to magnification, no further magnification is possible. Magnification with the delayed sweep is advantageous in magnifying an optional portion of a comparatively low frequency signal.

There are two delayed sweep modes, namely, non-triggered mode and triggered mode.

Non-triggered Delay Sweep

In the previous operations, various controls have been set in various states. Now, for ease of delayed sweep operation, re-arrange the controls as follows.

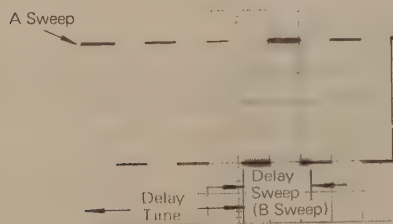
MODE	CH 1
VOLTS/DIV (CH 1)	1 V
VARIABLE <SS-4100G only>	CALIB
HORIZ DISPLAY	A
SWEEP MODE	AUTO
A TIME/DIV	1 msec
A VARIABLE <SS-4100G only>	CALIB

B TIME/DIV	.1 msec
SOURCE	INT CH 1
COUPLING	AC
SLOPE	+
INTENSITY	Moderate brightness

Connect the CAL 4 V connector to the CH 1 connector using the BNC cable, trigger the signal properly so that a stable waveform is displayed, and turn the HORIZ DISPLAY switch to the A INT BY B range. Any desired part (magnified and intensity-modulated) can be displayed on the CRT screen by turning the DELAY TIME knob.

The delay time adjustment can be very conveniently made because the single knob can be used for both coarse and fine adjustments. For coarse adjustment, turn the knob clockwise or counterclockwise slightly passing over the desired point. For fine adjustment, return the knob in the reverse direction. When this is done, fine adjustment can be made for a certain range. When the fine range is

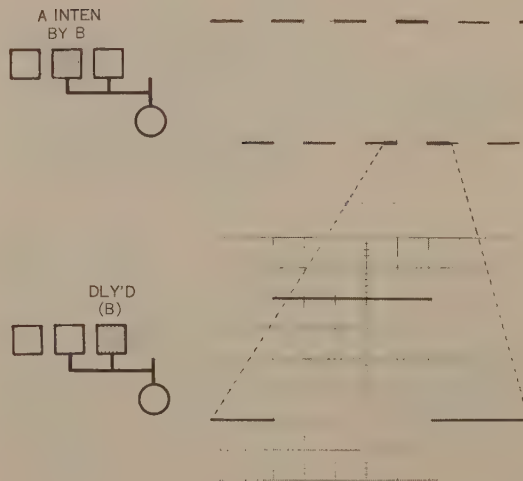
Figure 2-19 Non-triggered Delay Sweep



exceeded, the coarse adjustment resumes. The width of the magnified section is determined by the setting of the B TIME/DIV switch.

Next, push the DLY'D (B) button of HORIZ DISPLAY selector. When this is done, the section which has been

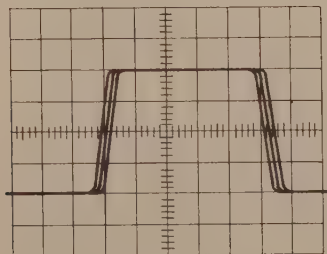
Figure 2-20 Magnification of Non-triggered Delay Sweep



selected by the A INT BY B will be displayed for the full graticule range as shown in Fig. 2-20. In this case, the magnification factor is determined by the relationship between sweep time of the A sweep and that of the B sweep. Turn for trial the DELAY TIME knob and see that the magnified waveform moves. You will be sure that any desired section of the waveform can be magnified and displayed by turning the DELAY TIME knob.

Turn the B TIME/DIV switch to the $1\ \mu\text{sec}$ position, and slowly turn the DELAY TIME knob until the leading and trailing edges of a square wave are displayed. Delay jitter (unstable horizontal trace) will appear as shown in Fig. 2-21, and accurate evaluation of the leading and trailing edges will be difficult. Thus, the delay jitter imposes a limit on magnification. The magnification factor, however, can be increased by using the following triggered mode of delay.

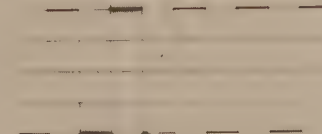
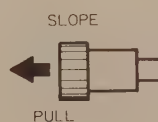
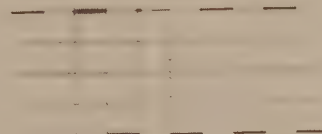
Figure 2-21 Delay Jitter



Triggered Delay

The triggered delay mode can be obtained simply by pushing the B MODE button under the above state. In this mode, the magnified part (intensity-modulated) will be triggered at the start of the A sweep. Then, turn clockwise the DELAY TIME knob. The delayed sweep part will intermittently jump from one leading portion of the A

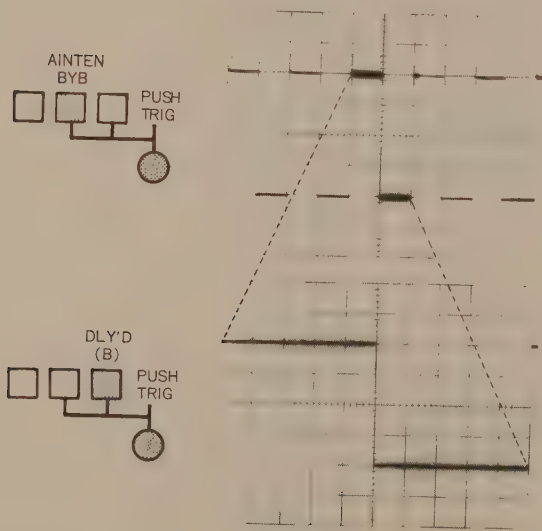
Figure 2-22 Triggered Delay Sweep



sweep to the other.

To delay intermittently the trailing edge, pull the SLOPE switch (set in the "—" position). Of the SS-4100/SS-4100G synchroscope, the trigger circuit is common for both A and B sweeps. It is impracticable to change

Figure 2-23 Magnification of Triggered Delay Sweep



independently the polarity of the B sweep alone. For triggering in synchronization with the trailing edge of the A sweep, the SLOPE switch must be set in the "—" state and the polarity of the A sweep must be inverted.

As mentioned in the above, either the leading edge or the trailing edge of the A sweep can be selected to start in synchronization with the magnified sweep. In this case, the horizontal amplitude of the magnified sweep is determined by the B TIME/DIV switch.

Next, push the DLY'D (B) button of HORIZ DISPLAY selector so that the magnified part of the waveform is displayed for the full range of the graticule as shown in Fig. 2-23. In this case, the magnification ratio is determined by the ratio between A sweep time and B sweep time. Turn the B TIME/DIV switch to the $1\mu\text{sec}$ position to magnify still more the displayed waveform. No jitter should appear. Therefore, a higher magnification factor can be obtained in this mode than in the non-triggered mode.

Under this state, the displayed waveform does not move when the DELAY TIME knob is turned. Actually, the magnified and displayed section is that which is selected by the A INT BY B button and is intensity-modulated.

SINGLE SWEEP OPERATION <SS-4100G only>

If a normal repetitive sweep is employed for observing a discharge waveform, chattering of relay contacts or other transient phenomena, the displayed waveform will appear to be out of synchronization as shown in Fig. 2-24. In such cases, the single sweep mode (one-shot mode) by which the signal is swept only once, will display a correct waveform. Since the display is not repeated, the waveform

is normally recorded by taking a photograph.

(A universal-type camera mount which is adaptable to almost all types of cameras is available from IWATSU. To employ this camera mount, the ordinary bezel of the SS-4100 or SS-4100G must be replaced with a special one (camera-mount bezel) which also is available from IWATSU. For the camera-mount bezel, refer to Section "OPTIONAL ACCESSORIES" at the end of this instruction manual.

The basic single sweep operation will be explained by using the calibration signal as the input signal. Connect the calibration voltage to the input, and set the controls as follows:

HORIZ DISPLAY	A
SWEEP MODE	NORM
VOLTS/DIV	Suitable position for adequate display
A TIME/DIV	Suitable position for adequate display

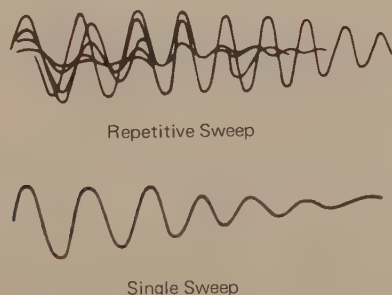
Adjust the triggering for a stable display and then press

the SINGLE button of the SWEEP MODE selector. The waveform will be displayed only once each time the RESET button is pressed.

Next, disconnect the cable of the calibration voltage at the INPUT connector, and press the RESET button. The circuit is now reset to a waiting condition (to actuate a single sweep when a trigger signal is applied), and the READY lamp lights to indicate this status. A single sweep can be actuated by connecting the calibration signal to the input. The waiting status may not be obtained when the LEVEL control is close to its mid-position. In this case, adjust the LEVEL control slightly. Simultaneous observation of dual trace waveforms in the ALT mode under the above single sweep operation (one-shot operation) is impossible.

The single sweep operation is also possible under the external trigger mode by applying an external trigger signal through the EXT TRIG INPUT connector and operating the required controls of the synchroscope in the same manner as is made for the internal trigger.

Figure 2-24 Single Sweep Signal



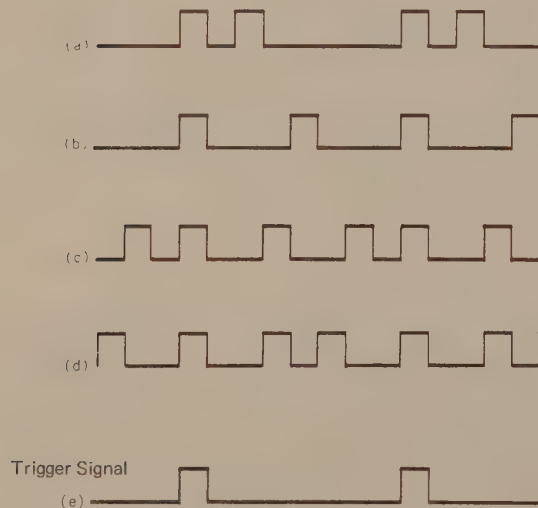
AND GATE OPERATION <SS-4100 only>

Of the SS-4100 synchroscope, external triggering can be made in two modes. One is that the sweep is triggered by the trigger signal applied through the TRIG INPUT connector. The other is that the sweep is triggered by the signal(s) applied to the AND GATE connector(s). When the EXT button of SOURCE selector is pushed to select the external trigger mode of operation, the EXT TRIG SELECTOR switch which is located on the right side panel also must be set as required.

When the switch is set in the NORM position, the

sweep is triggered by the AND logic signal of one to four signals which are applied to the AND GATE connectors. For example, for comparative display of waveforms (a) through (d) shown in Fig. 2-25, signals (a) through (d) must be connected to AND GATE connectors and the INPUT connector of the vertical deflection circuit as shown

Figure 2-25 AND GATE Signals

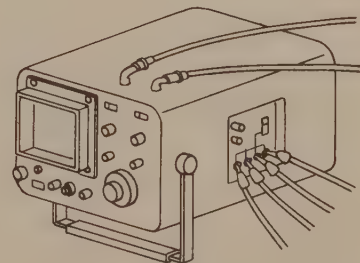


in Fig. 2-26. (Since there are dual vertical channels, one of the four signals should be used as a reference signal and the other signals should be connected in turns.)

Since the trigger signal is an AND logic signal of the four signals, triggering is made stably for all signals with the signal (e) which has certain time relationships with respect to all four signals.

The signals applied to the AND GATE connectors should be +5 Vp-p. The MONITOR terminal is used to monitor the AND GATE output signal.

Figure 2-26 Connection of Signals to AND GATE Connectors



VARIABLE SWEEP LENGTH

In general observation the sweep length is fixed at approximately 11 div on the graticule. However, if required, the sweep length is continuously variable for a range of approximately 3.5 div to 11 div by means of the A SWEEP LENGTH control located on the right side panel. There are two major uses of the A SWEEP LENGTH control as follows.

Observation of Complicated Pulse Trains

In observation, for example, of a complicated pulse train waveform as shown in CH 1 of Fig. 2-27, triggering is apt to be synchronized and double display may be produced as illustrated in Fig. 2-27 (b). Such double display can be effectively eliminated by means of the A SWEEP LENGTH control.

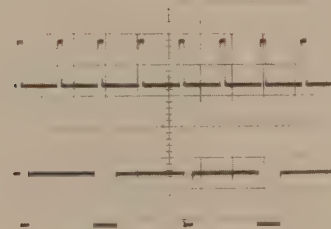
The operation method of the A SWEEP LENGTH control is as follows: Slightly turn counterclockwise the A SWEEP LENGTH control from its extremely clockwise position (locked position) to vary the sweep time so that the sweep always start from the same point of the waveform. This will ensure stable triggering.

Trace Intensification

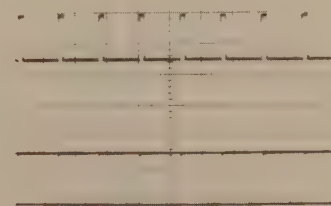
The A SWEEP LENGTH control also can be used to brighten the trace. In general, the trace intensity is decreased as the sweep speed is increased. This is especially true when the sweep speed is greatly increased in the delayed sweep magnification or in the sweep magnification with the MAG switch. In such a case, the displayed section of the waveform may be set as close to the starting point of the sweep as possible in order to eliminate the unneces-

sary section of the sweep. As a result, the sweep repetition frequency for the displayed section is increased and the trace brightness is increased.

Figure 2-27 Observation of Complicated Pulse Train Waveform —



(a) With the A SWEEP LENGTH Control



(b) Without the A SWEEP LENGTH Control

SWEEP STOP OPERATION

When the SWEEP STOP button is pushed, the sweep stops and a spot is displayed at the sweep start position.

With the state that the NORM button of SWEEP MODE selector has been pushed, if no trigger signal is being applied or the LEVEL control is being set exceeding the trigger point, the sweep stops and the CRT beam is stationary (in a standby state). Actually, no spot is displayed on the CRT screen even if the trace intensity is increased. If the SWEEP STOP button is pushed (turned on) under the above state, a spot brighter than the trace is displayed on

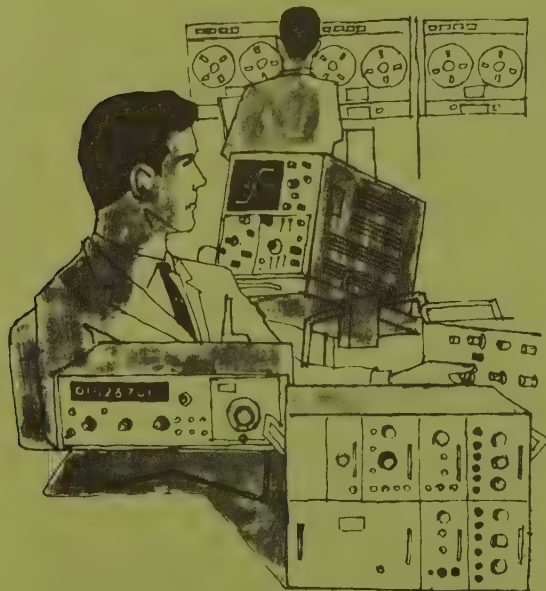
the CRT screen for position identification.

In servicing computers, such cases are often encountered that one cycle of operation is instructed to be performed by the computer and existence or absence of a pulse for a certain computer circuit is to be checked. In the SWEEP STOP mode of operation, the trace is horizontally stationary and is deflected only vertically. Therefore, this mode can be used for convenient observation of a single pulse (one-shot pulse) signal.

In the SWEEP STOP mode of operation, adjust the spot to an appropriate brightness by means of the INTENSITY control.

SECTION 3 MEASUREMENT

Various measurement procedures and their application will be described in this section. Refer to sections 1 and 2 for technical characteristics and basic operating procedures of this instrument.



CONNECTION OF INPUT SIGNAL	3- 2
PROPER USE OF PROBE	3- 6
PREPARATIVE PROCEDURE	3- 8
VOLTAGE MEASUREMENT	3-10
CURRENT WAVEFORM MEASUREMENT	3-13
TIME MEASUREMENT	3-13
FREQUENCY MEASUREMENT	3-20
PHASE MEASUREMENT	3-22
MEASUREMENT OF NON-ELECTRICAL PHENOMENA	3-22

CONNECTION OF INPUT SIGNAL

The input impedance of this instrument, viewed from the INPUT connector, is composed of 1 megohm resistance and 30 pF of parallel capacitance. When the accessory probe (1017B1, 1017B2) is used, the resistance increases to 10 megohms and the capacitance decreases to 15 pF or less, thus reducing the influence of the oscilloscope on the circuit to be measured.

The signal to be observed may be connected to this instrument with conventional insulated wire, shielded cable, probe, or coaxial cable. The type of cable should be selected in accordance with the following conditions:

Output impedance of signal source

Amplitude and frequency of signal

Presence of external induction noise

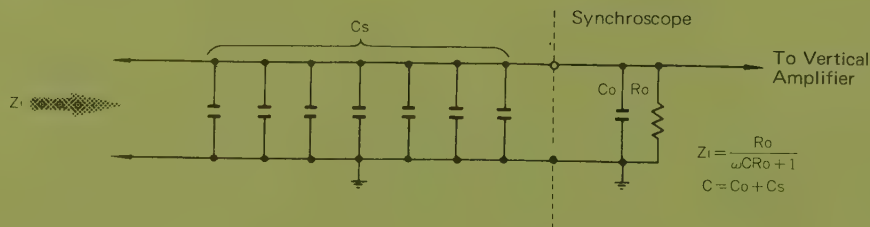
Distance between instrument and signal source

The preferred connection methods, classified in accordance with the type of input signal, are shown in Table 3-1.

Table 3-1

Type of Input Signal		Distance	Connection Method				
			Insulated wire	Shielded cable	Probe	Coaxial Cable	Others
Low Frequency	Low imp.	Short	O	O	O		
		Long		O		O	
	High imp.	Short		O	O		
		Long		O			
High Frequency	Low imp.	Short			O	O	
		Long				O	
	High imp.	Short			O	O	
		Long					O

Figure 3-1 Input Impedance when Insulated Wire is used



The various connection methods will now be described in detail.

Connection of Signal with Conventional Insulated Wire

Remove the insulation from both ends of the insulated wire and connect one end to the INPUT connector. The wire can be connected to the INPUT connector by using the adaptor (BNC-BP-12D) provided for this purpose. This method is simple and does not attenuate the signal to be measured.

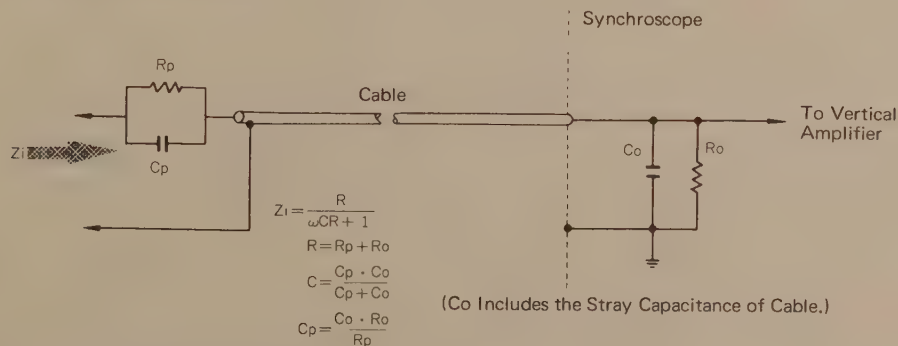
However, if there is a considerable distance between the signal source and the oscilloscope and/or a magnetic field is present in the vicinity of the measuring cable, noise may be induced and affect the measurement. This induction is

apparent when the impedance of the circuit to be measured is high.

Stray capacitance between a conventional insulated wire and ground is also considerably large, and the input capacitance viewed from the circuit to be measured becomes: (stray capacitance C_s) + (instrument input capacitance C_o).

The influence of this method on the circuit to be measured is greater than that of the probe (attenuation ratio 10:1). For example, assuming the output impedance of the signal source to be $1\text{ k}\Omega$ with a frequency of 1 MHz, and the input capacitance (stray capacitance of cable plus input capacitance of instrument) to be 100 pF, the signal source output is equivalently shunted by a resistance of $1.6\text{ k}\Omega$. The equivalent resistance of the cable becomes 1.6 Megohms at 1 KHz and the influence on the signal source is considerably reduced.

Figure 3-2 Input Impedance when Probe is used



The use of conventional wire is suitable mainly for low frequency and low impedance measurements.

Use of Shielded Cables

The use of shielded cable protects the signal from externally induced noise, however, the capacitance of this cable (from 50 pF/m to 100 pF/m) limits the use of shielded cable at high frequencies.

Shielded cable is advantageous to eliminate the influence of static induction.

Use of Probe

When the accessory probe (attenuation ratio is 10:1) is used, the influence of external induction is also eliminated since the input cable is shielded as shown in Fig. 3-2. In

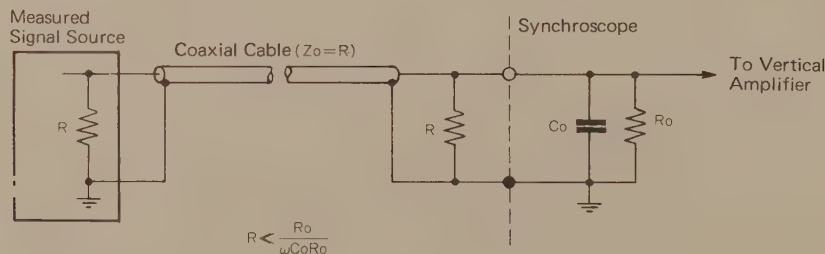
addition, the wide range attenuator composed of attenuating resistor R_p , shunted capacitor C_p , the instrument input resistor R_o and shunted capacitor C_o , ensures accurate measurement even when the measured signal frequency is high and the output impedance of the signal source is large.

Since the input capacitance of the probe (viewed from the probe tip) is approximately 15 pF, the input impedance of the probe is 10.61 k Ω at 1 MHz and is comparatively higher than that in the previously described method.

However, the probe has some disadvantages as the input signal is attenuated by 1/10, and the cable length is limited. A cathode follower probe may be used so that the input capacitance is reduced without reducing the input signal.

When the 10:1 probe is used for high frequency signal observation, in order to prevent waveform distortions,

Figure 3-3 Feeding the Input Signal with a Coaxial Cable



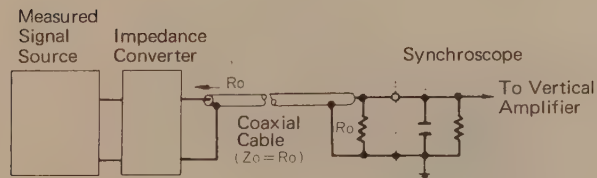
ground the shield line of the probe in a position as close to the input signal source as practicable by means of the ground clip.

Use of Coaxial Cable

When the output impedance of a signal source is $50\ \Omega$, $75\ \Omega$, $93\ \Omega$ or $125\ \Omega$, the use of coaxial cable with the same characteristic impedance will enable high frequency signals to be coupled without attenuation.

It should be noted that the coaxial cable must be properly terminated at the instrument side for impedance matching, as shown in Fig. 3-3 to avoid distorting high frequency signals.

Figure 3-4 Long Distance Feeding of Signal (1)

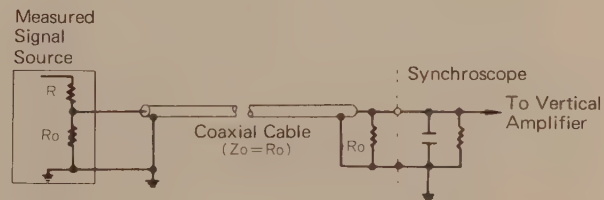


Other Methods

For accurate measurement of a remote signal source having high frequency and high impedance, an impedance converter must be used to match the circuit impedance to that of the coaxial cable ($75\ \Omega$, for example) which is used to connect the signal to the instrument. A transformer may be used for a narrow bandwidth measurement, but a cathode follower or similar circuit is preferred for wide band measurements. (Refer to Fig. 3-4.)

When the output level from the measured circuit is high, the input signal to the vertical amplifier may be voltage-divided by a divider of which output impedance is matched to the coaxial cable impedance, as shown in Fig. 3-5.

Figure 3-5 Long Distance Feeding of Signal (2)



PROPER USE OF PROBE

Advantages of Use of Probe

The probe can be advantageously used in the following purposes:

- (1) For accurate measurement of a high frequency signal from a high output impedance signal source:

When the probe is used, the input impedance is increased to $10\text{ M}\Omega$ with 15 pF in parallel. This impedance, which is much larger than the case in which the input signal is directly fed to the INPUT connector, imposes less load effect on the signal source. (If the load effect is large, the source voltage itself may be reduced or its waveform may be distorted.)

- (2) To eliminate external noise:

The signal conductor wire of the probe is shielded and is free from external induction noise. The original signal alone is fed to the synchroscope, ensuring clean and accurate observation and measurement. However, since the accessory probe which accompanies the synchroscope is of a 10:1 attenuation ratio, the source signal is attenuated to 1/10 before it is fed to the input connector. The maximum available probe cable length is 2 meters.

- (3) For high voltage measurement:

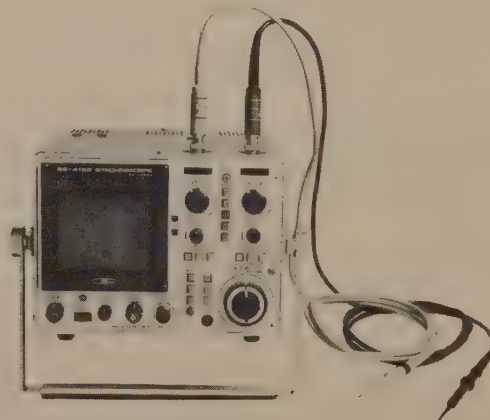
The vertical deflection sensitivity of the SS-4100/SS-4100G is 10 V/cm maximum. The graticule scale is 8 div. Therefore, if a voltage higher than 80 Vp-p is directly applied to the INPUT connector, the waveform will be over-deflected off the graticule range. In such a case the 10:1 attenuation probe can be effectively used to reduced the input voltage. When the probe is used, the maximum sensitivity is reduced to 100 V/div . Even such a large voltage as

500 V is displayed with an amplitude of 5 div within the graticule range. Furthermore, by connecting a high voltage capacitor at the tip of the probe, measurement can be made up to the rated voltage of the capacitor.

Connection of Probe

Connect the probe(s) to the CH 1 and/or CH 2 INPUT connector(s) as shown in Fig. 3-6. The connectors are BNC type.

Figure 3-6 Connection of Probes



Probe Phase Calibration

In measuring a waveform employing a probe, unless the probe phase has been correctly calibrated of its phase, a false waveform could be displayed on the viewing area. Prior to measurement, the probe must be correctly phase-calibrated following the below-mentioned procedure.

Connect the probe to the INPUT connector and CAL 4 V connector. Set the VOLTS/DIV switch in the .1 V position to display the waveform with an amplitude of 4 div. Adjust the variable capacitor of the probe so that a correct waveform as shown in Fig. 3-8 (a) is obtained. (The flatness of the waveform is varied as the variable capacitor is turned.) When the calibration is made with the VOLTS/DIV switch in the .1 V position, calibration for the other positions should be automatically accomplished. If calibrations for the other positions actually are not made

Figure 3-7 Probe Phase Calibration

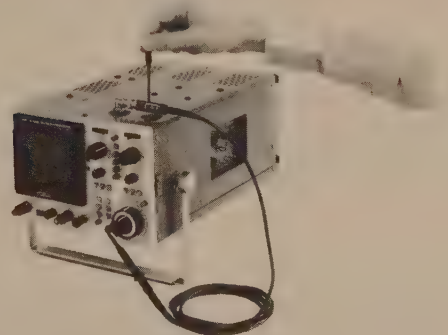
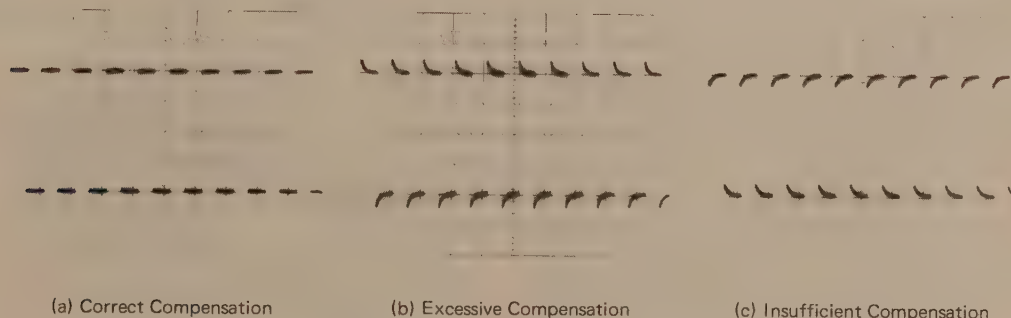


Figure 3-8 Probe Phase Waveforms



automatically, refer to SECTION 6, PHASE OF VOLTS/DIV.

Probe Accessories

The probe is used to pick up the measured signal by contacting its tip to the signal source. Tips of various configurations and probe accessories as shown in Fig. 3-9 are available. Their uses are tabulated in Table 3-2.

Table 3-2

Accessory	Use
Retractable hook tip	The brim is retractable towards the cord and the tip end can be hooked on the measured object.
Straight pin tip	Used to pick up a signal from a small object.
Screw adaptor	The thread diameter of tip mount base of this probe is 2.6 mm. This adaptor enables to couple a 4-mm diameter tip to this probe.
Ground lead	This lead must always used for high frequency signal measurement. Securely insert the spring-loaded section in the hole.
Probe holder	The probe when not in use is hung on this holder to protect its tip.

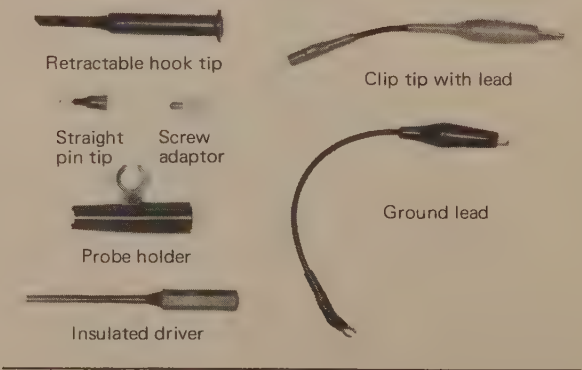
PREPARATIVE PROCEDURE

To ensure accurate measurement, the controls (variable resistors) of the top panel and graticule illumination must be properly adjusted prior to starting measurement. This preparative procedure is explained below referring to Figs. 2-5 and 2-6.

ASTIG Adjustment

For accurate measurement with less errors, the waveform displayed in the viewing area must be focussed sharp. The ASTIG (astigmatism) control, in conjunction with the FOCUS control, is used for best focussing of the trace for the full scale on the CRT screen.

Figure 3-9 Probe Accessories



For focus adjustment, turn at first the INTENSITY control to obtain an appropriate trace brightness. Next, adjust the FOCUS control to obtain an appropriate trace image. Then, adjust the ASTIG control to obtain uniform focus of the trace. Repeat the focus and astigmatism adjustments until the sharpest trace image is obtained.

TRACE ROTATION Adjustment

Unless the horizontal trace (base line) is parallel with the graticule scale, errors are introduced as the waveform is observed at the right hand end and left hand end. To align the horizontal trace line with the graticule lines, proceed as follows: First, move the horizontal trace line to

the graticule center by means of the vertical POSITION control. Next, turn the TRACE ROTATION control on the top panel so that the trace line is made parallel with graticule scale lines.

When the position (posture) of the synchroscope is changed, the adjusted parallelism may be disturbed by the effect of the terrestrial magnetism. The synchroscope must be fixed in a certain position when the trace rotation adjustment is made.

GAIN Calibration

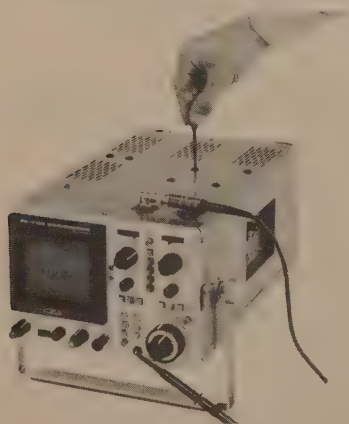
Prior to measurement, ensure that the gain has been correctly calibrated. To check the gain, set the VOLTS/DIV switch in the CAL 4 V position so that the calibration voltage is internally connected to the vertical circuit and a square wave with an amplitude of 4 div is displayed on the graticule. Check that the amplitude is accurately 4 div. If the amplitude has been deviated, adjust it accurately to 4 div by turning the GAIN control on the top panel.

For measurement with a probe, the gain may be calibrated including the probe. For this calibration, connect the probe to the INPUT connector and CAL 4 V connector as shown in Fig. 3-10 and set the VOLTS/DIV switch in the .1 V position. Under this state, turn the GAIN control on the top panel so that the vertical deflection amplitude is made accurately 4 div.

Vertical Balance Adjustment <SS-4100 only>

The measuring efficiency is degraded unless the vertical deflection system following the input circuit is well DC balanced. For CH 1, adjust the CH 1 POSITION ADJ so that, with the POSITION control set in the mid-position, the trace is positioned in the vertical center of the graticule.

Figure 3-10 Gain Calibration



For CH 2, adjust the CH 2 POLARITY BAL control so that the displayed trace is not vertically shifted when the CH 2 POLARITY (PUSH INV) button is pressed.

DC BAL Adjustment <SS-4100G only>

Unless the vertical deflection system following the input circuit is well DC balanced, the displayed trace may be vertically shifted as the VARIABLE control is turned. Adjust the DC BAL control to eliminate the vertical shifting.

The adjusted state of DC balance, of both models mentioned above, is rarely varied after being correctly established once. However, note that it may be disturbed if variation of ambient temperature is abnormally large.

SCALE ILLUM Adjustment

The illumination of the graticule is adjustable with the SCALE ILLUM control on the top panel. Adjust this control so that an appropriate graticule illumination is obtained. The illumination increases as the control is clockwise.

VOLTAGE MEASUREMENT

Quantitative Measurement

With the SS-4100, the quantitative value of the input signal voltage can be directly read referring to the value indicated by the VOLTS/DIV switch.

With the SS-4100G, the quantitative value of the input signal voltage can be directly read referring to the value indicated by the VOLTS/DIV provided that the VARIABLE control is set in the CALIB position (extremely

clockwise position). When the VARIABLE control is not in the CALIB position, the quantitative value cannot be directly read but can be indirectly known through calculations as below.

- (1) Determine the vertical amplitude of the display on the graticule.
- (2) Keeping the above settings of the VOLTS/DIV switch and VARIABLE control unaltered, apply the CAL 4 V output signal to the INPUT connector. The vertical deflection sensitivity at these positions is then calculated employing the below equation (3-1).

$$\text{Vertical deflection sensitivity (V/div)} = \frac{\text{CAL 4 V output signal (= 4 volts)}}{\text{Vertical amplitude of CALIB output signal (div)}} \dots\dots\dots (3-1)$$

After the vertical deflection sensitivity has been calculated employing equation (3-1), the quantitative value of the input signal can be known from equation (3-2).

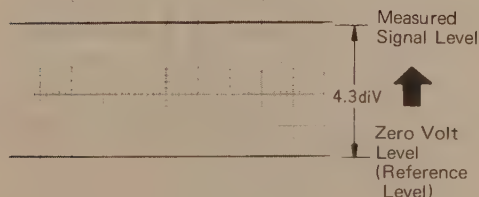
$$\text{Input signal voltage (V) = Vertical deflection sensitivity (V/div) x Displayed amplitude (div)} \dots\dots\dots (3-2)$$

The calibration output signals of both SS-4100 and SS-4100G are fixed at 4 V. When the calibration is required to be made with respect to a voltage other than 4 V, apply an external signal (which is known to be accurately at the required voltage) to the INPUT connector, and calculate the quantitative value of the unknown input signal voltage using the above equations (3-1) and (3-2).

DC Voltage Measurement

For DC voltage measurement, proceed as follows: Display a trace in the free run mode and select a fast sweep time so that the trace will appear steady. Set the AC-GND-DC switch in the GND state. Now the vertical position of the trace represents the reference line (zero volt level). Move the zero volt level to a position convenient for measurement (such as shown in Fig. 3-11, for example). Turn the AC-GND-DC switch to the DC state, apply the DC signal to the instrument, and read the distance between the displayed DC signal level and the zero volt level on the

Figure 3-11 DC Voltage Measurement



graticule. If the signal level is deflected beyond the viewing area, turn the VOLTS/DIV switch to a position where the signal level reading can be conveniently made.

If the level line is deflected upward of the zero level when the DC signal is applied, the polarity of the signal is positive; if it is deflected downward, the signal is negative. However, when the signal is applied through the CH 2 INPUT connector and the CH 2 POLARITY selector is set in the NORMAL state, the signal voltage can be known by using equation 3-3 or 3-4 where "A (div)" denotes the deflection distance from the zero volt level to the deflected signal level.

When signal is directly applied to the INPUT connector:

$$\text{Voltage (V)} = \text{VOLTS/DIV indication} \times \text{A (div)} \quad (3-3)$$

When 10:1 probe is used:

$$\text{Voltage (V)} = \text{VOLTS/DIV indication} \times 10 \times \text{A (div)} \quad (3-4)$$

For example, assuming that the level deflection amplitude is 4.3 div as shown in Fig. 3-11 and that the VOLTS/DIV switch is set in the 2 V position, the signal voltage is calculated with equation (3-3) as follows:

$$2 \text{ V/div} \times 4.3 \text{ div} = 8.6 \text{ V}$$

Assuming also that the 10:1 probe is used, the signal voltage is calculated with equation (3-4) as follows:

$$2 \text{ V/div} \times 10 \times 4.3 \text{ div} = 86 \text{ V}$$

AC Voltage Measurement

If the AC-GND-DC switch is set in the DC position to measure an AC signal superimposed on a DC component and if the DC component is large as compared with the AC component, the AC component may be deflected off the viewing area due to the large DC component.

In such a case, it may be possible to bring the AC component waveform back into the viewing area by turning of the POSITION control. It also is possible to bring back the waveform by turning the VOLTS/DIV switch so that the overall waveform amplitude is reduced. With such a reduced deflection amplitude, however, accurate measure-

ment cannot be expected.

For accurate measurement in such a case as above, the AC-GND-DC switch must be set in the AC position so that the DC component is eliminated and the AC component alone can be displayed with a sufficiently large deflection amplitude for accurate measurement.

Denoting the displayed amplitude with "A div", the AC voltage can be calculated employing equation (3-3) or (3-4). It should be noted that, when the AC-GND-DC switch is set in the AC position, the displayed amplitude is attenuated at low frequencies (-3 dB attenuation at 3 Hz). When the probe is used, the amplitude is attenuated -3 dB at approximately 0.3 Hz.

The AC signal voltage calculated from equation (3-3) or (3-4) represents the peak-to-peak voltage (V_{p-p}). For calculation of the effective voltage (V_{rms}), equation (3-5) must be used.

$$\text{Voltage (V rms)} = \frac{\text{Voltage (Vp-p)}}{2\sqrt{2}} \quad \dots\dots\dots (3-5)$$



Assuming that a waveform as shown in Fig. 3-12 is displayed on the graticule and that the VOLTS/DIV switch is set in the .5 V range, the peak-to-peak voltage of the AC signal is calculated as follows:

$$.5 \text{ V/div} \times 3.6 \text{ div} = 18 \text{ V}$$

The r.m.s. value is calculated with equation (3-5) as follows:

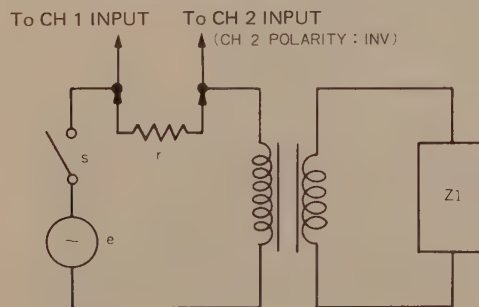
$$18 \text{ V} \div 2\sqrt{2} = 7.37 \text{ V}$$

CURRENT WAVEFORM MEASUREMENT

CRT oscilloscopes, including synchroscopes, are designed to measure voltage signals only. Electrical signals other than voltages, and all other physical quantity signals such as mechanical vibrations, etc. must be converted into voltage signals before they are fed to the input connectors of synchroscopes. This is true for the SS-4100/SS-4100G also.

For electrical current measurement, insert a known resistor in the measured circuit and measure the voltage drop across the resistor using the synchroscope. The

Figure 3-13 Current Waveform Measurement in Differential Mode



current is then calculated with Ohm's Law, $I = E/R$. The resistor used for this purpose must be sufficiently small so as not to change the characteristics of the signal source.

When resistor insertion is impracticable since the signal source circuit is forbidden to be open-circuited, use a current probe. By the use of this probe, measurement can be accomplished keeping the signal source circuit intact.

When the signal source circuit is isolated from the ground as shown in Fig. 3-13, accurate measurement of the signal with a conventional single input instrument is impossible. A differential amplifier is required. As described in DUAL TRACE MEASUREMENT AND SUM OR DIFFERENCE OF TWO SIGNALS in SECTION 2, the SS-4100/SS-4100G has a differential signal measuring function.

For this measurement, proceed as follows: Push the ADD button of the MODE selector and push the CH 2 POLARITY switch to set it in the INV state. Connect the probe tips of the CH 1 and CH 2 probes across the inserted resistor (r). Set the CH 1 and CH 2 VOLTS/DIV switches in the identical positions. Now the waveform across the resistor (r) which represents the measured current is displayed on the CRT screen.

TIME MEASUREMENT

Time Interval Measurement

The time interval between two optional points on a waveform can be read directly from the TIME/DIV indication. For time interval measurement, proceed as below. For the SS-4100G, however, the A VARIABLE control must be set in the CALIB position.

Push the A button of HORIZ DISPLAY selector and

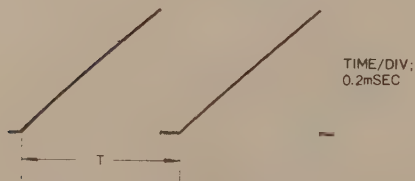
display a stably triggered waveform. Set the A TIME/DIV switch in a position which facilitates reading of distance T as shown in Fig. 3-14. The time interval between the two points is calculated from equation (3-6).

$$\begin{aligned} \text{Time T (sec)} = & \text{TIME/DIV indication (sec/div)} \\ & \times \text{distance between the two points on} \\ & \text{graticule} \times \text{reciprocal of MAG switch} \\ & \text{value} \dots\dots\dots (3-6) \end{aligned}$$

The reciprocal of the magnifier value is 1 when the display is not magnified and it is 0.1 when magnified.

Of the example shown in Fig. 3-14, the distance

Figure 3-14 Time Interval Measurement



between the two points is 5 div. Time (T) is calculated from equation (3-6) as follows:

$$0.2 \text{ msec} \times 5 = 1 \text{ msec}$$

Assuming that the MAG switch is set in the ON state, time (T) is calculated as follows:

$$0.2 \text{ msec} \times 5 \times 1/10 = 0.1 \text{ msec.}$$

Difference of Time Between Two Signals

The time difference between two signals is easily

Figure 3-15 Measurement of Time Difference between Two Signals

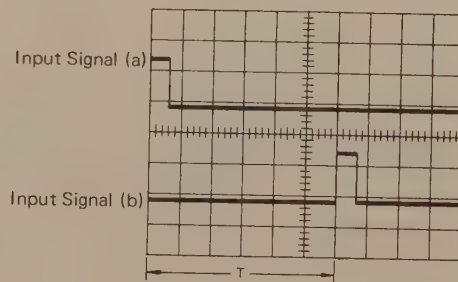
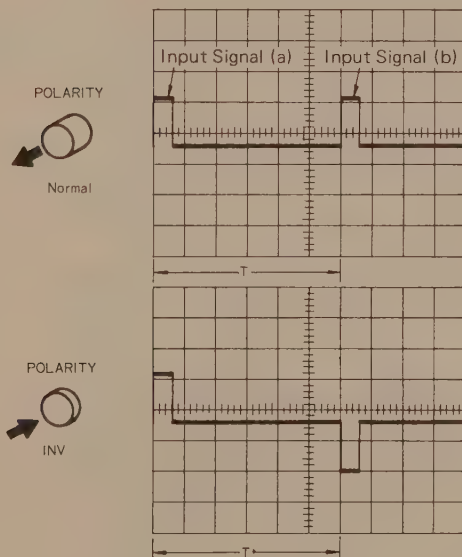


Figure 3-16 Time Difference Measurement in ADD Mode



measured by using the ALT, CHOP, or ADD mode dual trace operation of this instrument. Fig. 3-15 illustrates an example of measurement in the ALT or CHOP mode and Fig. 3-16 that in the ADD mode.

In these modes, the display must be triggered with the leading signal with respect to time. In other words, the SOURCE selector must be set to select the channel of the signal which is leading the other with respect to time. (In the illustrated example, the button which selects the channel to which input signal (a) is connected must be pushed.) Read the distance (T) and calculate the time between the two signals from equation (3-4).

Observation of Pulse Waveform

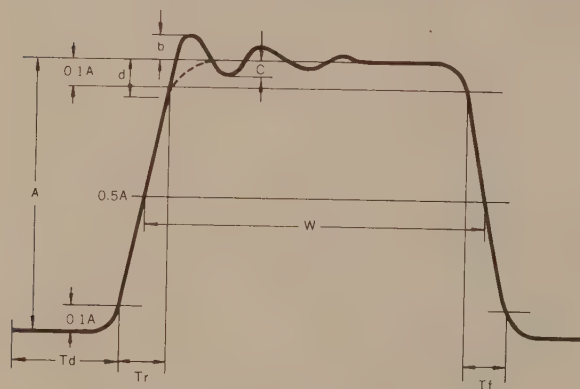
The most of the signals used in computers and other digital apparatus are pulse waves. A theoretically ideal pulse waveform consists of a fundamental frequency and infinite number of harmonics. For analysis of a pulse circuit, the waveform of the pulse signal must be observed and evaluated. For evaluation of the pulse waveform, terminology as mentioned below is used. (Refer to Figs. 3-17 and 3-18.)

1. Overshoot
Undesirable short-period peak superimposed on the leading edge of the basic pulse waveform.
2. Ringing
Wavering portion which follows the leading edge of the pulse waveform.
3. Tilt
Falling of the pulse top which should normally be flat.
4. Rounding
Rounded portion of the leading edge of the pulse waveform, representing pulse response characteristics.

5. Rise time and fall time

The period in which the instantaneous value of the signal is varied between 10% and 90% of the basic amplitude of the waveform, representing pulse response characteristics.

Figure 3-17 Pulse Waveform Terminology



A : Basic Amplitude

 $\frac{b}{A}$: Overshoot $\frac{C}{A}$: Ringing

W : Pulsewidth

 T_r : Rise Time T_f : Fall Time $\frac{d}{A}$: Rounding T_d : Signal Delay Time

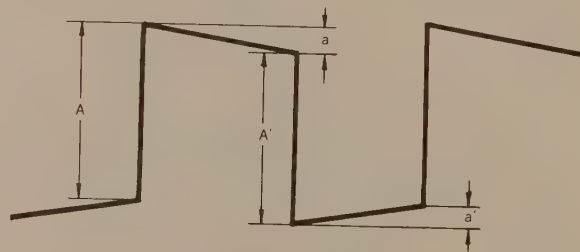
6. Pulsewidth

The period between two points where the instantaneous value of the signal becomes 50% of the basic amplitude of the waveform, representing the pulse response characteristics.

7. Signal delay time

The period from the start of time axis sweep to the instant when the instantaneous value of the signal at the leading edge becomes 10% of the basic amplitude of the pulse waveform.

Figure 3-18 Waveform with Sag



A : Basic Amplitude

a : Tilt

$$\text{Tilt} = \frac{a}{A} \text{ (or } \frac{a'}{A'}) \times 100\%$$

Either $\frac{a}{A}$ or $\frac{a'}{A'}$, whichever larger is used for the Tilt ratio.

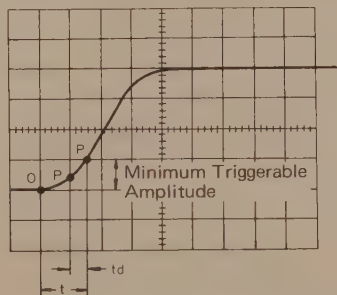
Observation of Leading (or Trailing) Edge of Pulse Waveform

A signal delay circuit is incorporated in the vertical deflection system of the SS-4100/SS-4100G. For observation of a pulse signal having a faster rise time (or fall time) as compared with the signal delay time (27 nsec), the synchroscope must be operated in the internal trigger mode so that the leading edge of the pulse signal can be easily displayed within the viewing area as illustrated in Fig. 3-19.

However, the leading edge of a signal having a slow rise time (or fall time) as compared to the signal delay time (as will be the case for a sound signal, mechanical shock, or other slow starting signal) cannot be successfully observed within the viewing area.

In other words, referring to Fig. 3-19, the signal is

Figure 3-19 Observation of Rising Edge of Pulse Waveform



When no signal delay cable is used, the sweep starts by point P.
When signal delay cable is used, the sweep starts by P' point.
td: Signal Delay Time

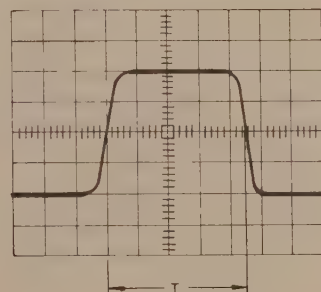
displayed on the viewing area starting by point P' which precedes point P (which represents the minimum triggerable amplitude) by signal delay period t_d ($=27$ nsec). In fact the signal to be measured starts at the zero point. The signal waveform for the portion of $t - t_d$ is missing from the viewing area. The EXT mode of operation must be used for measurement of such a fast rising (or falling) signal.

Pulsewidth Measurement

For measurement of a pulsewidth, proceed as follows: Deflect the pulse signal for a vertical amplitude of 2 div or 4 div from the vertical center line of the graticule.

Set the TIME/DIV switch to obtain an appropriate horizontal sweep length. Read on the graticule the distance

Figure 3-20 Pulsewidth Measurement



(T) between the two points where the pulse amplitude becomes 50% of its full amplitude or where the leading and trailing edges of the pulse waveform cross the horizontal center line of the graticule as illustrated in Fig. 3-20. The pulse width now can be calculated employing equation (3-6). When the pulsewidth is very narrow, magnify the displayed pulse waveform.

Measurement of Pulse Rise (or Fall) Time

Deflect the signal in the vertical and horizontal directions in the similar manner as in pulsewidth measurement. By means of the horizontal POSITION control, move the waveform so that its upper 10% level (of the example shown in Fig. 3-21, the 0.4 div level) crosses the vertical center line of the graticule. Read the distance (T_1) from

the horizontal center line to the point where the rising edge (or falling edge) crosses the horizontal center line.

Next, move the waveform by means of the horizontal POSITION control so that the lower 10% level of the waveform crosses the vertical center line. Read the distance (T_2) from the horizontal center line to the point where the rising edge (or falling edge) crosses the horizontal center line. The rise time (or fall time) can be obtained by substituting ($T_1 + T_2$) into equation (3-6).

Precautions in Pulse Measurement

In measurement of rise time and fall time of the pulse waveform, attention must be paid on the synchroscope's own rise-time response characteristics and input capacitance.

Rise-time characteristics of SS-4100/SS-4100G

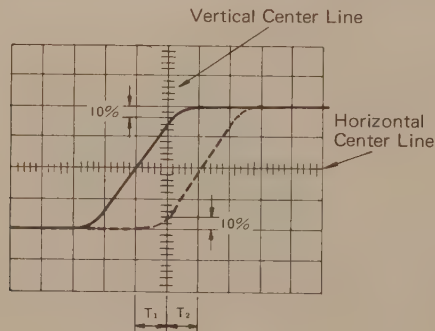
The rise-time response of the SS-4100/SS-4100G is 35 nsec. This value has been calculated from the relationship between the rise time and the frequency bandwidth determined by equation (3-7). This value represents the period required for the displayed waveform to rise up to a certain level when an ideal pulse wave (theoretical zero rise time pulse) is applied to the SS-4100/SS-4100G.

$$T_s = \frac{0.35}{F_s} \quad \dots\dots\dots (3-7)$$

where, T_s : Rise time
 F_s : Frequency bandwidth

When the rise time (or fall time) of the measured pulse is much larger than that of the SS-4100/SS-4100G (35 nsec), the effect of the latter on the former is negligible. When

Figure 3-21 Pulse Rise (Fall) Time Measurement



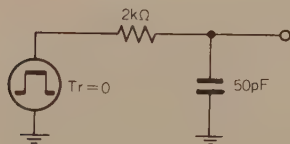
the former is very short, however, the effect of the latter will cause errors. In such a case, the measured value must be corrected employing equation (3-8).

$$T_r = \sqrt{T^2 - T_s^2} \quad \dots\dots\dots (3-8)$$

where, T_r : True value
 T : Measured value
 T_s : Rise time of SS-4100/4100G (35 nsec)

For example, when a pulse signal having a rise time of 175 nsec (5 times of 35 nsec rise time of SS-4100/SS-4100G) is measured with the SS-4100/SS-4100G, the pulse signal will be displayed as a waveform having a rise time of 178 nsec ($T = \sqrt{175^2 + 35^2} = 178$ nsec). The result includes an error of approximately 2% of the true

Figure 3-22 Pulse Signal Source



value (175 nsec). In practice, however, errors of this order will be permissible.

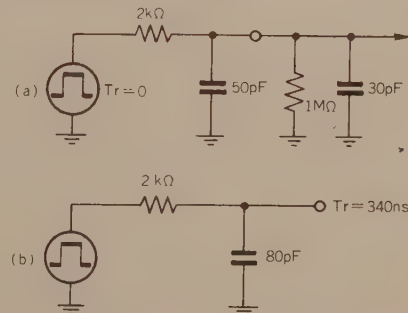
In general, errors will be tolerable if the rise time of the measured signal is more than 5 times of that of the synchroscope. If the former is less than 5 times of the latter, the measured value should be compensated by using equation (3-8).

Effect of Input Capacitance

The input impedance (RC) of the SS-4100/SS-4100G is 1 MΩ with 30 pF in parallel, of both CH 1 and CH 2. As viewed from the INPUT connector, the above fact is equivalent to a fact that a 1 MΩ resistor and a 30 pF capacitor are connected in parallel between INPUT connector and ground.

Let us discuss the effect caused by the input impedance

Figure 3-23 Load Effect of Input Capacitance



of the SS-4100/SS-4100G when the pulse signal to be measured is fed from a signal source as illustrated in Fig. 3-22, for example.

Assuming that the output impedance of the signal source is 2 kΩ and 50 pF, the rise time of the pulse signal is calculated to be “tr = 2.2 × 2 kΩ × 50 pF = 220 nsec” from equation (3-9) which gives the relationship between CR time constant and pulse rise time.

tr = 2.2 RC (3-9)

Since the rise time of the SS-4100/4100G is 35 nsec, it is negligible with respect to 220 nsec. However, the maximum measurable pulse waveform in this case is degraded to approximately 340 nsec. It is not that a pulse wave having a rise time of up to 220 nsec is measurable on the graticule.

The reason for the above is as follows: When the output of the signal source shown in Fig. 3-22 is connected to the INPUT connector of the SS-4100/SS-4100G, the input resistance and capacitance are connected as shown in Fig. 3-23 (a). The input resistance (1 MΩ) causes no loading effect on the signal source since it is much larger than the output resistance (2 kΩ). However, the input capacitance (30 pF) causes a substantial effect on the signal source since the overall parallel capacitance increases to 83 pF as shown in the equivalent circuit of Fig. 3-23 (b). Consequently, the rise time becomes “tr = 2.2 × 2 kΩ × 80 pF = 340 nsec.”

As described in the above, when a fast-rising pulse signal from a small-output-capacitance signal source is to be measured, attention must be paid on the effect caused by the input capacitance of the synchroscope itself. If the load effect of the input capacitance is large, it also will cause errors in pulswidth measurement.

The loading effect of the input capacitance can be reduced by using the accessory probe. The input impedance (RC) as viewed from the input circuit of the probe is 10 MΩ and 15 pF.

When the pulse signal from the source shown in Fig. 3-22 is measured with the probe, the signal will be displayed as an waveform having a rise time of 286 nsec (tr = 2.2 × 2 kΩ × 65 pF = 286 nsec). This is a substantial improvement over the case the pulse signal is directly fed to the INPUT connector.

FREQUENCY MEASUREMENT

There are two major methods of frequency measurement.

The first method is as follows: The time (period) of one cycle is observed on the graticule as shown in Fig. 3-24 and is calculated from equation (3-6). Then, the frequency is calculated from equation (3-10).

Frequency f (Hz) = $\frac{1}{\text{Period (sec)}}$ (3-10)

In the example shown in Fig. 3-24, the length of one cycle is 8 div and the TIME/DIV switch is set in the 1 μsec/div position. Therefore, the period (T sec) and frequency (f Hz) are calculated as follows:

T (sec) = 8 div × 1 μsec/div = 8 μsec
f (Hz) = $\frac{1}{8 \times 10^{-6} \text{ (sec)}}$ = 125 × 10³ = 125 kHz

The second method is as follows: The number of cycles (N) displayed in 10 scale divisions, as shown in Fig. 3-25, is counted. The frequency is calculated from equation (3-11) using known N.

$$\text{Frequency } f (\text{Hz}) = \frac{1}{\text{TIME/DIV switch indication} \times 10} \quad \text{..... (3-11)}$$

This method is more accurate than the former method,

and the frequency measuring accuracy approaches the sweep time accuracy provided that the number of cycles (N) is sufficiently large. However, when N is comparatively small, reading the value of N below the decimal point becomes inaccurate and errors are introduced.

In the example shown in Fig. 3-25, N is 34.5 and the TIME/DIV switch indication is 1 msec. Therefore, the frequency (f Hz) is calculated as follows:

$$f (\text{Hz}) = \frac{34.5}{1 \times 10^{-3} \times 10} = 3.45 \times 10^3 = 3.45 \text{ kHz}$$

Figure 3-24 Frequency Measurement (1)

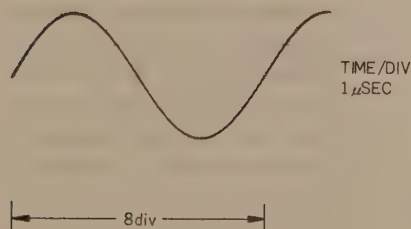
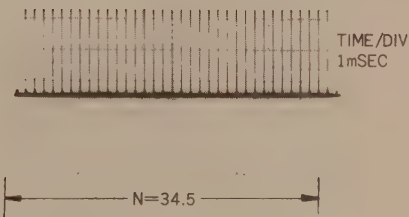


Figure 3-25 Frequency Measurement (2)



PHASE MEASUREMENT

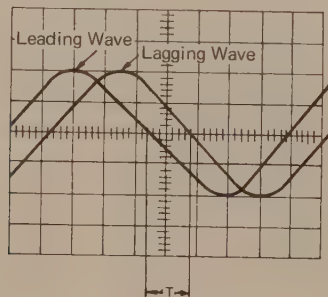
Fig. 3-26 illustrates an example of phase measurement between two sine waves, operating the synchroscope in the dual-trace mode. For INT trigger, the SOURCE selector must be set to select the signal of the leading phase as for the trigger signal.

Set the TIME/DIV switch so that one cycle is displayed in exactly 9 div. One vertical division represents 40° , since one cycle = $2\pi = 360^\circ$ is being displayed in 9 div. The phase difference between the two signals is calculated by equation (3-12).

$$\text{Phase difference (degree)} = \text{Horizontal distance between leading wave and lagging wave (T) } \times 40^\circ \dots\dots (3-12)$$

In the example shown in Fig. 3-26, T is 1.4 div and the phase difference is calculated to be " $40^\circ \times 1.4 = 56^\circ$."

Figure 3-26 Phase Measurement



MEASUREMENT OF NON-ELECTRICAL PHENOMENA

Voltage is the only electrical phenomenon which can be measured directly on a synchroscope. Synchrosopes, however, are widely used for measuring phenomena other than voltage as a result of the development of transducers which convert these phenomena into voltage. Transducer type measurements are now practiced in various fields such as kinetics, optics, temperature, and chemistry.

A summary of typical transducers will be described in the following paragraphs.

MEASUREMENT OF KINETIC VARIATION

The following properties of material under external force are employed to convert kinetic variations such as displacement, distortion, pressure, or vibration, into electrical variations.

- (1) Resistance variations of wire resistors and semiconductors due to externally applied force. These devices are known as strain gages.
- (2) Piezoelectric elements such as quartz crystals or barium titanate which produce an electrical output proportional to an externally applied force.
- (3) Capacitance pickup which varies its internal capacitance in accordance with an externally applied force.
- (4) Ferromagnetic pickup which varies its magnetic properties with external force.
- (5) Electromagnetic pickup which converts displacement into electromagnetic force.

Various other types of transducers are also produced. All these transducers are attached either directly or through

an adequate material to the object being measured.

These transducers may be classified according to their purpose, such as distortion measurement, pressure, or vibration, etc. These devices can be further classified into types which operate at high temperature or humidity, high frequency, large amplitude vibration, and those which are extremely sensitive for minute vibrations, etc.

Various new transducers are being developed, and additional applications using synchroscopes for measuring physical properties are expected.

Optical and Temperature Measurement

Transducers which convert light variations into electrical variations are commonly known as photoelectric cells and phototransistors. Photomultiplier tubes are used for detecting very dim or minute changes of light.

Thermistors, of which electrical resistance varies with temperature, and thermocouples composed of two dissimilar metals which generate an electromotive force when their junction point is heated, are the most commonly used thermal transducers.

MEMO

4

SECTION 4 CIRCUIT DESCRIPTION

This section will describe the operating principle of the SS-4100/SS-4100G to aid in the maintenance and calibration of the instrument.

Overall operation will be described first, referring to the block diagram shown in Fig. 4-1. Detailed descriptions of individual circuits will follow.

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BASIC OPERATING PRINCIPLE

A block diagram of the SS-4100/SS-4100G is shown in Fig. 4-1. All blocks operate for the final purpose of displaying a signal(s) on the CRT screen.

The vertical deflection system has two vertical preamplifiers for channels 1 and 2. Each preamplifier converts its input signal into a balanced signal. The outputs of both vertical preamplifiers are fed to the switching circuit. The diode gate of the switching circuit determines the connection of the input(s) (CH 1, CH 2, or both) to the signal delay circuit.

The display operation mode of the synchroscope is determined by the setting of the MODE selector. A single signal is displayed when the CH 1 or CH 2 button of MODE selector is pushed. The two input signals are simultaneously displayed when the ALT or CHOP button is pushed. The mathematic sum or difference of the two input signals is displayed when the ADD button is pushed. In the ALT mode, the diode gate is switched by a trigger signal from the A sweep generator, and the signals of CH 1 and CH 2 are alternately displayed in complete waveforms. In the CHOP mode, the two signals are chopped, irrespective of the sweep rate, at a repetition rate of approximately 200 kHz. In this mode, the switching waveform (chop blanking pulse) is applied to the Z axis amplifier to blank transients of the switching.

The signal which has been selected by the switching circuit is fed to the main amplifier through the signal delay circuit which retards the signal by approximately 120 nsec.

The main amplifier amplifies the balanced signal to a sufficient level to deflect the electron beam of the CRT.

A part of the signal fed to the INPUT connector is separated from the preamplifier and fed to the trigger amplifier. This signal is referred to as trigger signal. The

trigger signal is fed to the trigger circuit

The trigger generator converts the trigger signal into trigger pulses having a constant rise time and a constant amplitude. Regarding the SS-4100G, trigger pulses also can be generated with an external signal applied through the TRIG INPUT (EXT TRIG INPUT) terminal or with a line frequency trigger signal. Regarding the SS-4100, trigger pulses also can be generated with external signals which are applied through the AND GATE terminals in order to be subjected to an "and" logic.

The trigger output signal of the trigger generator drives both A and B sweep generators which produce respective sawtooth sweep signals. To provide a delayed sweep operation, a part of the output of the A sweep generator is fed to the B sweep generator. On the other hand, unblanking signals are fed from the A and B sweep generators to the Z-axis amplifier.

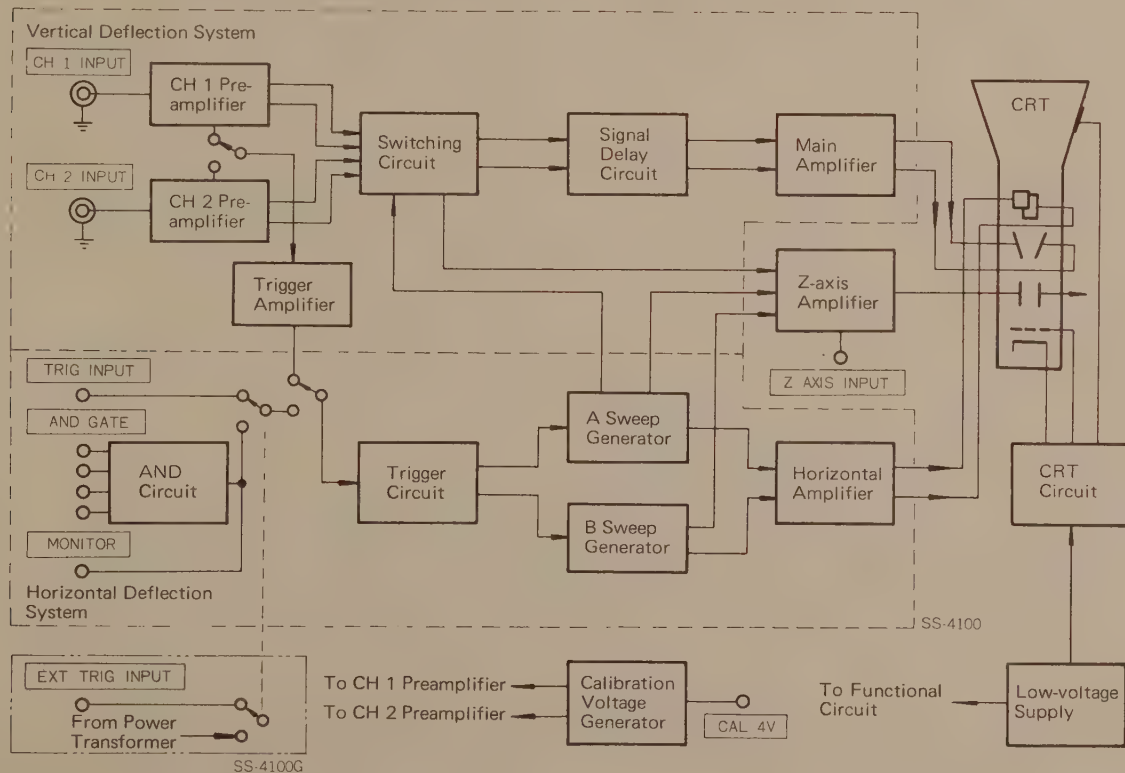
The horizontal amplifier amplifies the A and B sweep signals to a sufficiently high power level to deflect horizontally the electron beam of the CRT.

The Z-axis amplifier amplifies the unblanking signals fed from the A and B sweep generators, the chop blanking pulse signal fed from the switching circuit, and the external intensity modulation signal fed through the Z AXIS INPUT connector. The amplifier also handles the voltage signal determined by the INTENSITY control. These signals are fed to the deflection plates of the CRT in order to control the trace intensity.

The CRT circuit produces the high voltage required to emit and accelerate the electron beam.

The low voltage supply circuit provides the 6.3 V AC used for the CRT filament and graticule illumination lamps and the low DC voltages required for the operation of the other functional circuits of the synchroscope.

Figure 4-1 Basic Block Diagram of the SS-4100/SS-4100G



The calibrator circuit produces a reference pulse signal for calibration of sensitivity and sweep time. This signal is connected to the calibration positions of VOLTS/DIV switches of both channels and is externally available through the CAL 4 V output connector.

DESCRIPTIONS OF INDIVIDUAL CIRCUITS

The operations of individual circuits will be described here, referring to block diagrams and functional diagrams, and to SECTION 8 DIAGRAMS.

VERTICAL INPUT & ATTENUATOR

Input Signal Coupling

The input signal connected to the INPUT connector is fed to the input attenuator through the AC-GND-DC switch. When the switch is set in the AC position, the DC component of the input signal is blocked by capacitor C001A (C001B for CH 2) and the AC component alone is fed to the attenuator. In the DC position, the input signal is directly fed to the attenuator. In the GND position, the input signal is isolated and the input circuit is grounded. The GND position can be used to check conveniently the zero level position, keeping the connected input signal intact.

Input Attenuator

The input attenuator is a phase-compensated 10-step attenuator used to change the vertical deflection sensitivity. At the maximum sensitivity setting of the attenuator or when the VOLTS/DIV switch is set in the highest sensitivity

position, the attenuation factor is unit (1) or the signal is not attenuated. As the switch is turned to less sensitive positions, the attenuation increases stepwisely to factors of 1/2, 1/5, and so forth. Even when the switch is turned or the attenuation factor is varied, the input resistance as viewed from the INPUT connector remains constant at 1 M Ω .

When the VOLTS/DIV switch is set in the VAL 4 V position, the input signal is isolated and the output of the calibration voltage generator circuit is internally connected to the vertical deflection circuit, facilitating the gain adjustment of the synchroscope.

CH 1 PREAMPLIFIER

A block diagram of the CH 1 preamplifier is shown in Fig. 4-2. The preamplifier amplifies the signal received from the input attenuator and feeds the amplified signal to the switching circuit.

Input Source Follower and Emitter Follower

A junction type FET (field effect transistor), Q102A, is used in the input source follower circuit, which is equivalent to a vacuum tube cathode follower. The input source follower provides a high input impedance to reduce the load effect on the signal source and to provide a low output impedance to drive the subsequent amplifier stage. Diodes D101A and D102A protect FET Q102A against abnormally large input voltage since the FET is not highly resistant against large inverse voltage. These diodes conduct when a signal of over 12 V is applied, causing a voltage drop across R102A and R103A to limit the signal amplitude.

Transistor Q103A provides DC balance of the input source follower. As for transistors Q102A and Q103A, twin FET's are used to minimize thermal drift. The CH 1 POSITION ADJ (CH1 DC BAL for SS-4100G), R102A, is a variable resistor used to control the balance of the input state amplifier.

Since the input source follower alone is insufficient to obtain an output resistance sufficiently low to drive the input stage amplifier, the emitter follower (Q104A and Q105A) is employed in addition in order to obtain an output impedance lower still. The output of the emitter is fed to the input stage amplifier and, at the same time, it is fed to the trigger amplifier through emitter follower Q101A.

Input Stage Amplifier

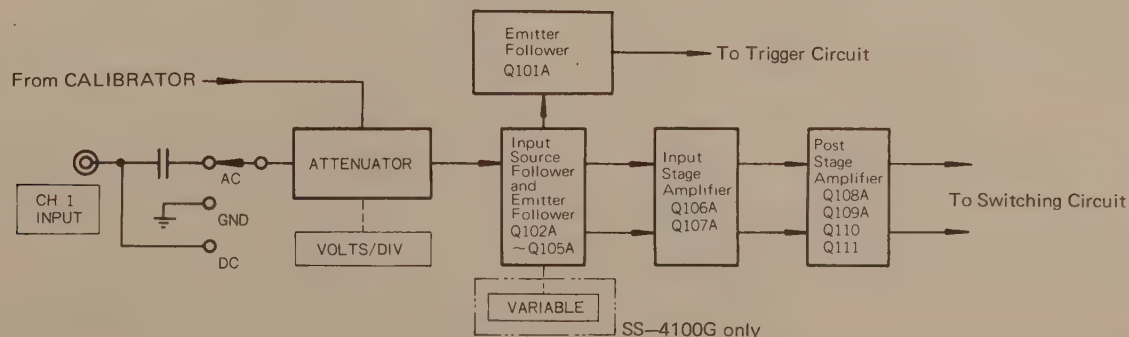
The input stage amplifier (Q106A and Q107A) is an emitter-coupled symmetrical amplifier (push-pull amplifier), and provides outputs of mutually opposite polarities (balanced output) at the collectors of these transistors.

Post Stage Amplifier

The post stage amplifier, together with the diode gate circuit (IC101) and negative-feedback amplifier which will be described later, makes up a compound amplifier. Operation of the compound amplifier will be covered in the description of the switching circuit.

The function of CH 1 GAIN R123A is to vary the

Figure 4-2 Block Diagram of CH 1 Preamplifier



emitter resistance to vary the gain and, in effect, to calibrate the deflection sensitivity. With the POSITION control, R128A, the collector potential of Q108A and Q109A is continuously variable for vertical positioning of the displayed waveform.

Regarding the SS-4100G, the VARIABLE control (R193A) which is connected between the emitters of Q106A and Q107A is used to vary continuously the impedance between emitters of Q106A and Q107A in order to obtain the required output attenuation.

CH 2 PREAMPLIFIER

The CH 2 preamplifier is basically identical with the CH 1 preamplifier. The only difference is that the CH 2 preamplifier has the POLARITY switch for inversion of the polarity of the displayed waveform. For the CH 2 preamplifier, suffix "B" is used instead of "A" for the CH 1 preamplifier. For example, a transistor of CH 2 preamplifier is denoted by Q101B while the counterpart transistor of CH 1 preamplifier is denoted by Q101A.

SWITCHING CIRCUIT

A functional diagram of the switching circuit is shown in Fig. 4-3. The diode gate, which is constructed in IC101, switches the connection of the balanced output from CH 1 or CH 2 preamplifier to the main amplifier.

Diode Gate

The diode gate of IC101 switches connection mode of the balanced signal from the post stage amplifier to the

negative feedback amplifier in accordance with setting of the MODE selector. When the CH 1 button of MODE selector is pushed, only the balanced signal from the post stage amplifier of CH 1 is fed to the negative feedback amplifier. When the CH 2 button is pushed, that of CH 2 alone is fed to the negative feedback amplifier.

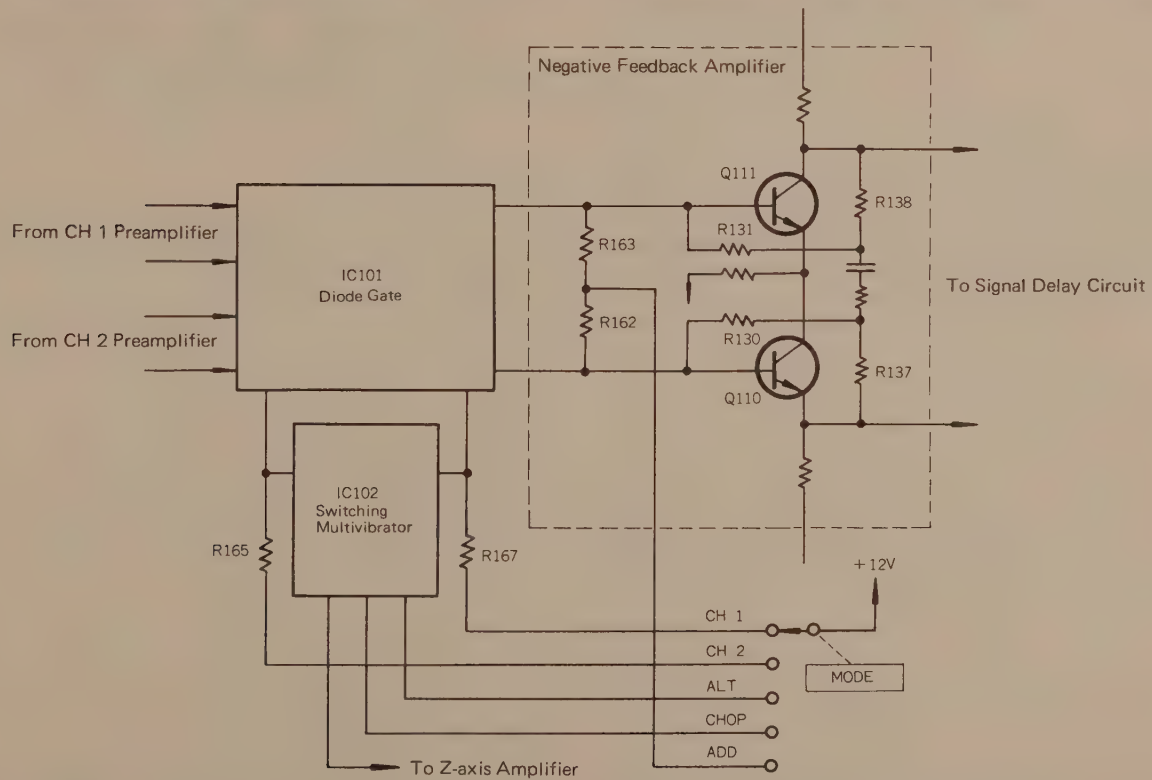
Switching Multivibrator

When the ALT button of MODE selector is pushed, the multivibrator which is constructed in IC102 operates as a bi-stable multivibrator. Each time a sweep is over, an alternate pulse is applied and the state of the multivibrator is inverted. The output of the multivibrator so controls the diode gate of IC101 that CH 1 and CH 2 are alternately selected each time a sweep is over and the output signals of CH 1 and CH 2 are alternately applied to the negative feedback amplifier.

When the CHOP button of MODE selector is pushed, the multivibrator operates as an astable multivibrator and oscillates at a frequency determined by its inherent time constant. The output of the multivibrator controls the diode gate of IC101. Therefore, irrespective of the sweep time, CH 1 and CH 2 are alternately switched each time the state of the multivibrator is inverted and the output signals of CH 1 and CH 2 are alternately applied to the negative feedback amplifier. On the other hand, the chop blanking signal is amplified by Q118 and Q119 and then is applied to the X-axis amplifier.

When the ADD button of MODE selector is pushed, the diode gate circuit is simultaneously opened for both CH 1 and CH 2, and the outputs of both channels are applied to the negative feedback circuit. In this case the circuit current is twice of that flows in CH 1 or CH 2 independent channel operation. Therefore, the current must be fed

Figure 4-3 Functional Diagram of Switching Circuit



through resistors R162 and R163 so that the operating point of the negative feedback amplifier remains unaltered.

Negative Feedback Amplifier

The negative feedback amplifier, together with the diode gate circuit and the CH 1 or CH 2 post stage amplifier selected by the MODE selector, makes up a compound amplifier which operates as the delay cable driver. Resistors R130, R131, R137 and R138 are used to reduce the impedance of the compound amplifier in order to drive the low impedance delay cable ($93\ \Omega$) and to prevent degradation of frequency response at high frequencies due to stray capacitance of the diode gate circuit elements.

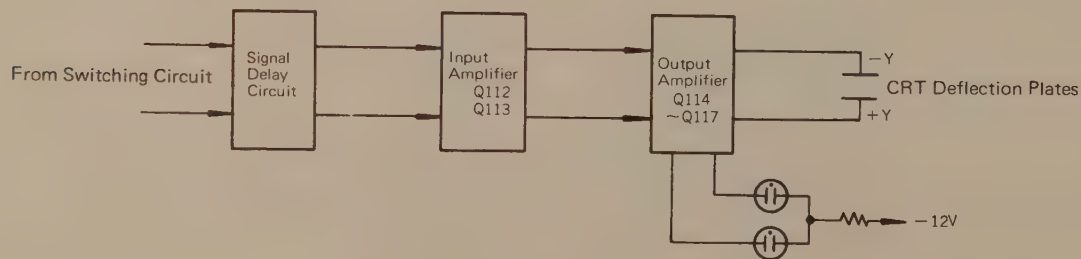
SIGNAL DELAY CIRCUIT

The output signal of the negative feedback amplifier is delayed by approximately 120 nsec as it passes the signal delay circuit (delay cable) and, then, it is applied to the main amplifier.

MAIN AMPLIFIER

The main amplifier consists of an input amplifier and output amplifier as shown in Fig. 4-4. The main amplifier amplifies the balanced signal received from the switching circuit, to a sufficiently high level to deflect the electron beam.

Figure 4-4 Block Diagram of Signal Delay Circuit and Main Amplifier



Input Amplifier

The input amplifier (Q112 and Q113) converts the balanced voltage signal (fed from the signal delay circuit) into a current signal. The gain of the input amplifier is determined by the ratio of $R153a \cdot b$ or $R154a \cdot b$ with respect to $R146$. The variable resistor, $R184$, is for compensation for matching distortion between the delay cable and the input amplifier.

Output Amplifier

The output amplifier, with its Q114, Q115, Q116 and Q117, amplifies the output signal of the input amplifier to a sufficiently high level to deflect the electron beam in the vertical direction. The negative feedback circuit consisting of $R153a \cdot b$ or $R154a \cdot b$ is incorporated to improve the frequency response.

Q116 and Q117 function as a load of Q114 and Q115 and, of the former transistors, the output signal is fed from their emitters in order to lower the output impedance. D105 through D108 are used for coupling of Q114 and Q115, and Q116 and Q117. Neon lamp NE101 or NE102 lights in response to deviation of the emitter voltage of Q116 or Q117 to identify the vertical position of the electron beam.

TRIGGER AMPLIFIER & AND CIRCUIT

< SS-4100 only >

As shown in the functional diagram of Fig. 4-5, this block consists of a trigger amplifier, an AND circuit, and various switching circuits. The trigger amplifier amplifies the trigger signal fed from the CH 1 or CH 2 vertical

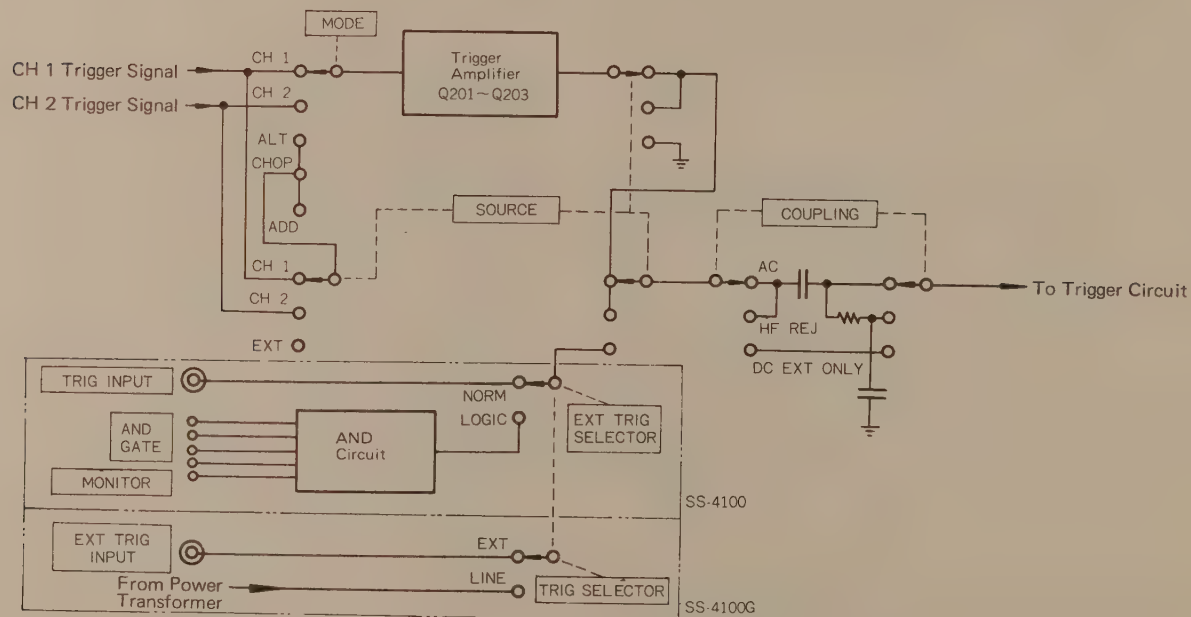
preamplifier. Regarding the SS-4100 only, the AND circuit produces a trigger signal in conformity with an "and" logic a plural number of input trigger signals which are simultaneously applicable up to four to the AND GATE input terminals.

Selection of Trigger Signal

The trigger signal is selectable with the MODE selector, SOURCE selector, and EXT TRIG SELECTOR (TRIG SELECTOR) selector. When the CH 1 or CH 2 button of MODE selector is pushed, a trigger signal is picked-off from the vertical deflection circuit and the signal is amplified by the trigger amplifier. The amplified trigger signal is fed to the coupling circuit when other button than EXT of the SOURCE selector is pushed; it is grounded when the EXT button of SOURCE selector is pushed. Therefore, when the CH 1 or CH 2 button of MODE selector is pushed, the trigger signal is selectable with the MODE selector alone irrespective of whether the CH 1 or CH 2 button of the SOURCE selector has been pushed. When the ALT, CHOP, or ADD button of MODE switch is pushed, the signal of either CH 1 or CH 2 is selected by the SOURCE selector and the selected signal is fed to the trigger amplifier.

When the EXT button of the SOURCE selector is pressed under the external trigger mode, the trigger amplifier output is grounded. Regarding the SS-4100, the external trigger signal which is applied to the TRIG INPUT or AND GATE terminal is fed to the coupling circuit in accordance with setting of the EXT TRIG SELECTOR switch. Regarding the SS-4100G, the external trigger signal which is applied to the EXT TRIG INPUT terminal or a line frequency trigger signal which is supplied from the power transformer is fed to the coupling circuit in accordance with setting of the TRIG SELECTOR switch.

Figure 4-5 Function Diagram of Trigger Amplifier and AND Circuit



Trigger Amplifier

The trigger signal picked-off from the vertical deflection circuit is fed to the emitter follower Q201. The output of the emitter follower is capacitance-coupled with C201 to Q202. The amplifier is incorporated with a feedback circuit consisting of R206 and C202 to improve its frequency response. Its gain (A) is given by the below equation:

$$A \doteq \frac{R206}{R208}$$

Diodes D202, D203 and D204 are used to bias Q202 so that it operates with its collector to emitter voltage at approximately 3 V.

AND Circuit <SS-4100 only>

The AND circuit is effected when the EXT button of SOURCE selector is pushed and the EXT TRIG SELECTOR switch is thrown to the LOGIC position. This circuit provides a trigger signal which is a result of an "and" logic operation on external signals applied to the AND GATE input terminals. The resultant signal is fed to the coupling circuit.

When the EXT TRIG SELECTOR switch is thrown to the LOGIC position, the +12 V power is supplied to R214 and is reduced to +2.6 V by voltage dividing resistors R214 and R216. The +2.6 V power is supplied to D205 through R215. On the other hand, the anode circuit of D205 is connected to the coupling circuit through the SOURCE switch.

Assuming that a signal which varies from 0 to 5 V is applied to J202, when the signal is 0 V (zero volt), the diode connected in series with J202 is driven into the

conducting state and a voltage of approximately 0.7 V will be produced in the anode circuit of D205. When the signal is 5 V, the diode is driven into the cut-off state and a voltage of approximately 2.6 V will be produced in the anode circuit. Consequently, an output signal which varies stepwise from approximately 0.7 V to approximately 2.6 V will be produced in the anode circuit of D205.

Now, let us assume that four different signals which vary from 0 V to 5 V are applied to the four terminals of J202 — J205. Under this condition, if the variations of the four signals do not completely synchronized or if any one of the four signals remains at 0 V, the voltage produced in the anode circuit of D205 will be 0.7 V. In other words, the voltage of the anode cannot be made 2.6 V unless the voltages of all four input signals are made 5 V synchronizably. Thus, the AND circuit produces an output signal which is the result of an "and" logic operation. This output signal is called "AND trigger signal" and is fed to the coupling circuit.

Selection of Trigger Signal Coupling

The mode of coupling of the trigger signal to the trigger generator is selectable with the COUPLING selector. When the AC button of COUPLING selector is pushed, the DC component of the trigger signal is blocked with capacitor C207 and the AC component alone (higher than approximately 50 Hz) is fed to the trigger generator. When the HF REJ button is pushed, the signal is coupled through the low pass filter which consists of C207, R212b and C208. This filter blocks the high frequency component and passes the low frequency component alone (approximately 30 Hz to 10 kHz).

When the DC button is pushed, the trigger signal is directly fed to the trigger generator. However, in the

internal trigger mode of operation, the internal trigger signal is coupled automatically in the AC mode irrespective of setting of the DC button of COUPLING selector.

TRIGGER GENERATOR

The construction of the trigger generator is as shown in Fig. 4-6. This generator produces a trigger pulse signal to drive the A and B sweep generators and an AUTO pulse signal to drive the A sweep generator for the AUTO mode of sweep operation.

Input Source Follower

The input source follower (Q301) provides a large input impedance for receiving the trigger signal from the coupling circuit and a small output impedance for feeding the signal to the shaping circuit and FULL AUTO circuit. Diodes D301 and D302 make up a limiter circuit to protect Q301 against abnormally large input voltage. These diodes conduct when the trigger signal level exceeds ± 12 V, effecting the amplitude limiting function with the voltage drop across resistor R301.

Pulse Shaper and Pulse Amplifier

These circuits consists of IC301, D305, Q306, and other components. These circuits determine the level and slope for triggering. The trigger signal is shaped into a square wave having a sharp rising edge and, then, it is converted into a narrow pulse signal (trigger pulse signal).

IC301 has a differential amplifier and a diode gate. The diode gate is opened or closed in accordance with setting of SLOPE switch S301. In conformity with

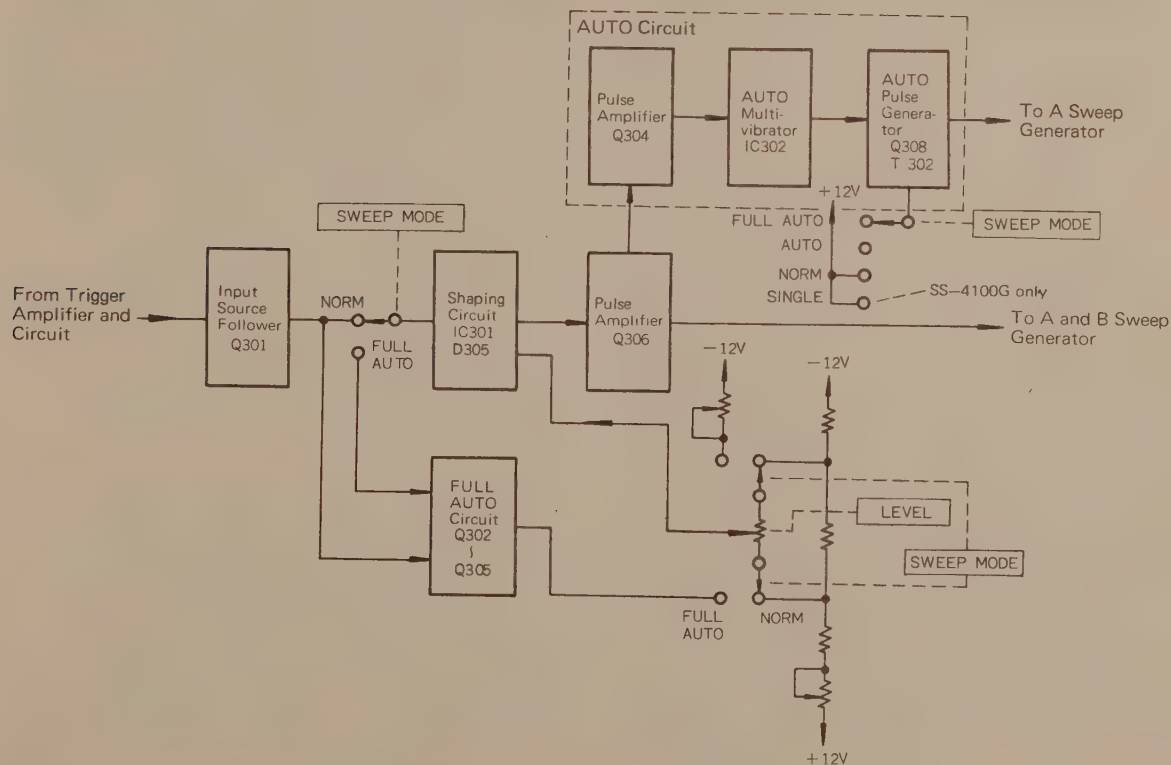
open/closed state of the diode gate, tunnel diode D305 is connected to transistor of either side of the differential amplifier. Tunnel diode D305 produces the trigger pulse signal in accordance with conduction and cut off of the transistor to which the tunnel diode is connected.

Let us assume that the SLOPE switch is set in the "+" state, a sine wave trigger signal as shown in Fig. 4-7 is applied to terminal No. 10 of IC301, and trigger level E_L is set by the LEVEL control through Q305. When the sine wave signal has reached the trigger level, the differential amplifier is subjected to a current switching operation. When the sine wave has increased to the level of period t_1 , the transistor of the differential amplifier (of the side to which the tunnel diode is connected) conducts and, consequently, the potential of terminal No. 2 of IC301 drops. Therefore, a current larger than I_p flows in D305, D305 jumps instantaneously from the low voltage region to the high voltage region, and the base voltage of Q306 varies stepwisely to a negative voltage. Due to this stepwise variation of the base current, Q306 conducts instantaneously through C310 and a positive pulse with a very narrow width is produced in the collector circuit of Q306.

When the peak of the sine wave is over at period t_1 , the potential of terminal No. 2 of IC301 rises, the current which flows in D305 becomes smaller than I_p and D305 is driven stepwisely into the low voltage region, and a negative pulse is produced in the collector circuit of Q306. However, negative pulses are eliminated by the limiter circuit consisting of D306, D307, and R325. Thus, positive pulses alone remains in the collector circuit of Q306. These positive pulses are polarity-inverted by T301 into negative pulses. These negative pulses drive the A and B sweep generators of the subsequent stage.

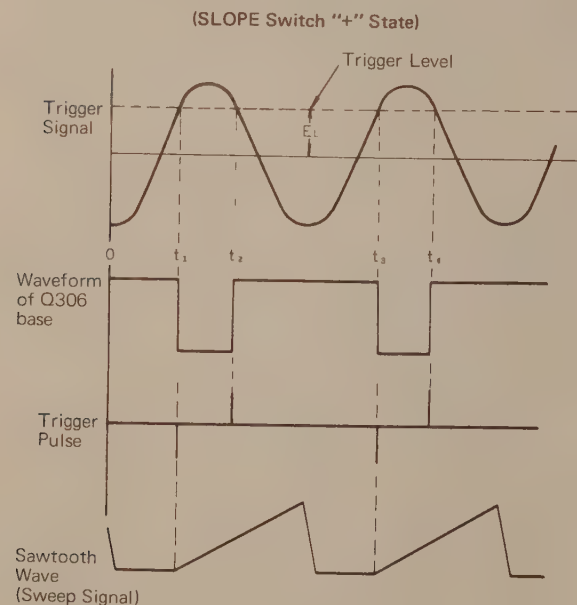
The timing of generation of trigger pulses are t_1 , t_3 ,.... and so forth as illustrated in Fig. 4-7. The sweep gener-

Figure 4-6 Block Diagram of Trigger Generator



ators are triggered with this timing to produce the sweep signals. The input signal amplified in order to be applied to the vertical deflection plates of the CRT is of the same phase with that of the trigger signal applied to terminal No. 10 of IC301. Therefore, by setting the SLOPE switch

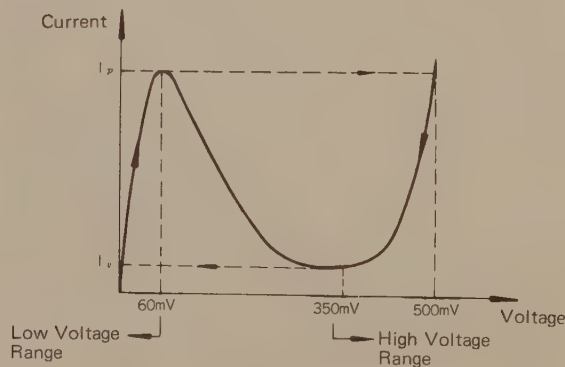
Figure 4-7 Trigger Signal and Trigger Pulses



in the "+" state, the sweep can be started by a point on the positive slope of the input signal waveform and the triggering point is adjustable by means of the LEVEL control.

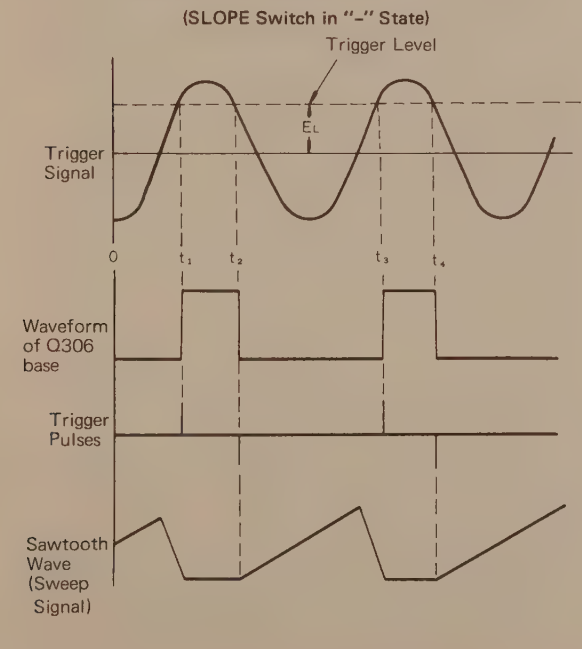
When the SLOPE switch is set in the "-" state, tunnel diode D305 is connected to the counterpart transistor of that to which D305 is connected when the switch is set in the "+" state. Variation of the potential of terminal No. 2 of IC301 is in the reverse of the case that the switch is in the "+" state. That is, as shown in Fig. 4-9, the trigger

Figure 4-8 Characteristic Curve of Tunnel Diode D305



signal is low for the period of 0 to t_1 , it is high for t_1 to t_2 , and it again is low for t_2 to t_3 . Tunnel diode D305 jumps from the low voltage region to the high voltage region when the potential of terminal No. 2 of IC301 drops. Therefore, trigger pulses are generated at the timing of t_2 , t_4 ... and

Figure 4-9 Trigger Signal and Trigger Pulses



so forth. Thus, the sweep can be started by a point on the negative slope of the input signal (trigger signal) waveform.

FULL AUTO Circuit

The function of the FULL AUTO circuit is effected when the FULL AUTO button of SWEEP MODE selector is pushed. In order that triggering is always effected at whatever level of the input signal setting of the LEVEL control, the extreme end voltages of the LEVEL control are set at the peak values of the trigger signal.

The input signal received from input source follower Q301 is fed to source follower Q302 of the FULL AUTO circuit. The trigger signal is clamped by C304 and D303, and the amplitudes of the negative peaks are limited at a certain level. The fixed-peak negative pulse signal as a trigger signal is fed to terminal No. 10 of IC301 through source follower Q302 and emitter follower Q303. The signal is also fed to the rectifier consisting of D304 and C305. The rectifier output is converted into a DC voltage corresponding to the peak value of the positive pulses of the clamped signal. This DC voltage is applied through emitter follower Q304 to one end of the LEVEL control (R311). As for the other voltage to be applied to the other end of the LEVEL control, a voltage corresponding to the peak value of the negative trigger pulses which are clamped by C304 and D303 is used. This voltage is obtained by reducing the -12 V supply with resistors R313, R316 and R341. Thus, a DC voltage corresponding to the peak-to-peak value of the trigger signal is applied through source follower Q305 to terminal No. 7 of IC301. D312 and D313 are used for temperature compensation for Q302 and Q303.

As described in the above, a voltage corresponding to the amplitude of the trigger signal is constantly applied to

the input terminals (Nos. 7 and 10) of the differential amplifier constructed in IC301. Therefore, so far as a trigger signal which has a sufficient amplitude to drive the differential amplifier is applied, the differential amplifier operates and trigger pulses are generated at whatever setting of the LEVEL control.

AUTO Circuit

The AUTO circuit consists of pulse amplifier Q307, AUTO multivibrator IC302, AUTO pulse generator Q308, and transformer T302. In the FULL AUTO mode or AUTO mode of operation, the A sweep generator operates either in the triggered mode or free-run mode according to existence or absence, respectively, of the trigger signal.

The operation of the AUTO circuit when no trigger signal is present is as follows: When the trigger pulse signal to be fed from Q306 is absent, the collector voltage of Q307 is clamped at approximately 0.6 V by D308. IC302 consists of a monostable multivibrator and switching transistors. When no trigger pulse is applied to input terminal No. 4, the monostable multivibrator is in its stable state and the switching transistor is in the cut off state and, therefore, the output terminal No. 10 is in the floating state. Consequently, D309 is not conducting and D310 is conducting. The current flows through D310, D338 and R337. The emitter voltage of Q308 is as given through the voltage divider consisting of R338 and R337. Transistor Q308 and its associated components make up a blocking oscillator which oscillates at approximately 500 kHz under the above condition, producing a negative AUTO pulse signal. This AUTO pulse signal is fed to the A sweep generator and drives it in the free-run mode which will be described in Sub-section "A SWEEP GENERATOR."

The operation of the AUTO circuit when the trigger

signal is present is as follows: When the trigger pulse is fed from the emitter of Q306 to the base of Q307, L302 presents an impedance for a high frequency signal (fast-changing signal) and, therefore, Q307 amplifies the negative pulses alone and produces positive pulses in its collector circuit. By this positive pulse signal, the mono-stable multivibrator of IC302 is inverted, the switching transistor is driven into the conducting state, and the potential of output terminal No. 10 becomes approximately +11 V. As a result, D309 is driven into the conducting state and D310 into cut off state, the emitter potential of Q308 rises, Q308 is driven into the cut off state, and the oscillation stops. Since no AUTO pulses are generated, the A sweep generator is set in the triggered state.

In the NORM mode of operation, since the +12 V supply is fed through R333, Q303 is completely in the cut off state and the A sweep generator is set in the triggered state irrespective of the trigger pulse signal. In this case, therefore, the sweep is produced when a trigger pulse is applied but no sweep is produced if no trigger pulse is applied.

A SWEEP GENERATOR

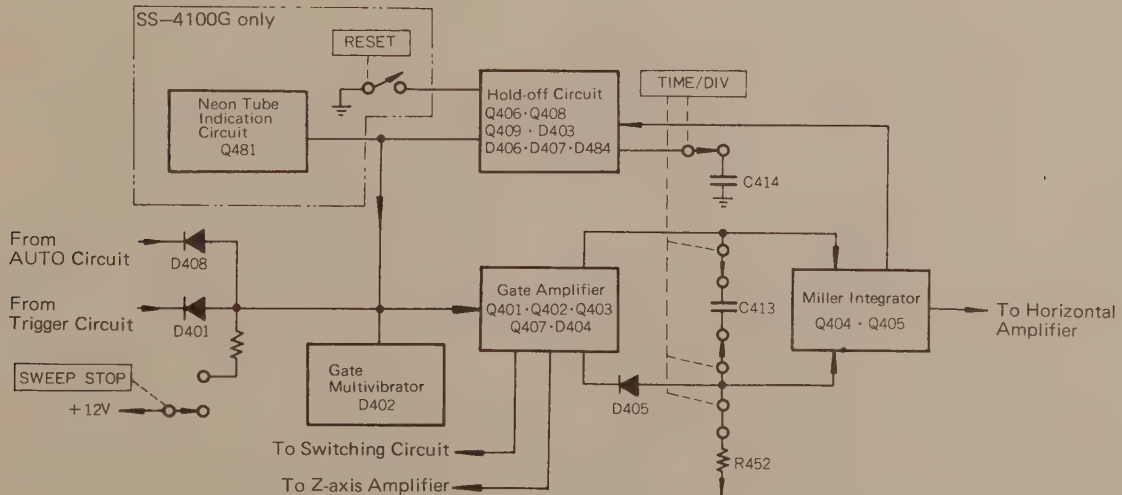
The circuit construction of the A sweep generator is as shown in Fig. 4-10. This sweep generator operates in the NORM mode and AUTO mode, and produces three signals as follows:

- (1) Sweep signal: The sweep signal (sawtooth wave) is amplified by the horizontal amplifier and is fed to the horizontal deflection plates of the CRT. The signal is also fed to the B sweep generator to produce the delay pulse signal.

- (2) Unblanking signal: This signal erases the unnecessary return trace of the sweep and displays the necessary trace alone on the CRT screen. This signal is amplified by the X-axis amplifier and is fed to the deflection plates of the CRT.
- (3) ALT signal: The ALT signal, which is used for the ALT sweep mode of operation, is fed to the switching circuit of the vertical deflection system.

The operation of the A sweep generator is as follows. The pulse signal fed from the trigger circuit drives gate multivibrator D402, the disconnecter diode D405 is driven into the cut off state, and the Miller integrator is driven into the operating state. During the steady state (no pulse is applied), D405 is in the conducting state and the Miller integrator remains in the steady state. When the trigger pulse signal is applied, the gate multivibrator is inverted,

Figure 4-10 Block Diagram of A Sweep Generator



D405 is cut off, and the Miller circuit produces a negative sawtooth wave signal. In this case the gradient of voltage drop is determined by C413 and R452 of the A TIME/DIV switch circuit.

When the voltage has dropped to a certain level, the comparator of the hold-off circuit is inverted, the gate multivibrator is inverted, D405 is driven into the conducting state, and Miller integrator is instantaneously discharged. This sharply rising voltage signal is slackened by the hold-off circuit and, after a certain delay time provided by C414, the voltage signal drives the gate multivibrator into the ready-for-trigger state through the comparator of the hold-off circuit. By the above operation, one cycle of sawtooth wave generation is complete. The sawtooth wave as a sweep signal is fed to the horizontal amplifier.

The unblanking signal is fed from the emitter of Q402 to the Z-axis amplifier. The ALT signal is fed from the collector of Q402 to the switching circuit of the vertical deflection system.

Normal Operation (Basic Operation)

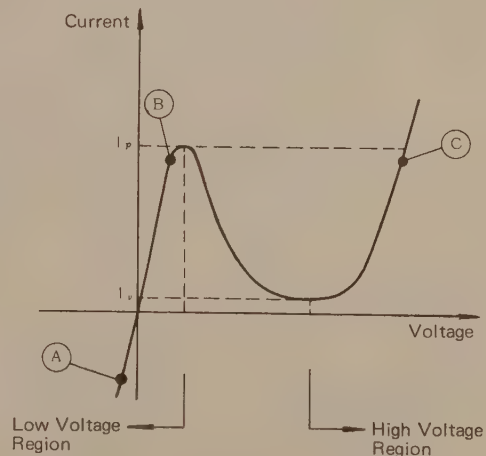
The steady state (no trigger pulse is applied and no sweep is effected) is as follows: D402 of the gate multivibrator is a tunnel diode with characteristics as shown in Fig. 4-11. When no trigger pulse is applied, the current of D402 is comparatively small and is operating at the (B) point of the low voltage region of the characteristic curve. The cathode potential of D402 in this case is in the positive side other than that when the operating point is in the high voltage region. Therefore, Q401 is cut off.

Since the base voltage of Q403 is fixed at approximately -4 V and Q401 is cut off, the collector voltage is low and the transistor is in the conducting state. Therefore, the voltage of Q403 is low (approximately -1.7 V) and dis-

connector diode D405 is in the conducting state. Consequently, Q405 is driven into the conducting state through source follower Q404.

If a slow sweep speed is selected under the above state, the resistance of the TIME/DIV switch circuit is increased

Figure 4-11 Characteristic Curve of Tunnel Diode (D402, D506) -



to approximately $20\text{ M}\Omega$ and, therefore, the input resistance of Q404 is required to be very high. To meet this requirement, a junction-type FET is used as for Q404 and the input resistance of Q405 of the Miller integrator is increased. Since the base voltage of Q403 is fixed at approximately -4 V , the collector voltage of Q405 is determined at approximately $+12\text{ V}$ by R436 and R437 through Q407.

As described in the above, in the steady state of operation, a linear feedback circuit is constructed as Q405—Q404—Q405—Q407—Q403—Q405. Due to the function of this feedback circuit, the collector voltage of Q405 remains constant when R452 is varied.

The operating state is as follows: When a negative trigger pulse is applied through D401 to the sweep generator which is in the steady state, the current of D402 exceeds I_p and its operating points jumps to the (C) point shown in the characteristic curve of Fig. 4—11. Consequently, Q401 is driven into the conducting state, the collector voltage rises, Q403 and Q407 are cut off, and the collector voltage of Q403 varies stepwise in the positive polarity to approximately $+0.7\text{ V}$. As a result, D405 is cut off, the Miller integrator consisting of Q404 and Q405 starts its integrating operation with an integrating constant determined by R452 and C413, the gate potential of Q404 starts rising linearly (as C413 is charged in the positive polarity through R452), and the collector voltage of Q405 falls linearly.

The operation of the hold-off circuit is as follows: The hold-off circuit consists of Q408, Q409, E403, D406, D407 and D484 (D484 is for SS—4100G only. The same applies hereunder.) When no sweep operation is being performed, D403 and D406 are in the cut off state.

Transistors Q408 and Q409 make up a comparator. When no sweep operation is being performed, the base voltage of Q408 is sufficiently high as compared with the fixed voltage ($+2\text{ V}$) of the base of Q409, and Q409 is conducting and Q408 is cut off, and the operating point of gate multivibrator D402 is in the low voltage region ((B) point of characteristic curve shown in Fig. 4—11).

When the trigger pulse is applied and the gate multivibrator is inverted, Q401 is driven into the conducting state. The base voltage of Q402 varies stepwise in the positive polarity and its collector voltage varies stepwise in the negative polarity, and D403 is driven into the conducting state. The charge which has been stored in C414 through R435 is discharged through D403, reducing the anode voltage of D403 and driving D407 and D484 into the cut off state.

When a sweep cycle is started, the collector voltage of Q405 starts falling. When the D406 cathode voltage which is connected through emitter follower Q406 has fallen below the base voltage of Q408, D406 is driven into the conducting state, the collector voltage of Q405 falls, and the base voltage of Q408 falls linearly. When the base voltage of Q408 has fallen below $+2\text{ V}$, the comparator is inverted and Q408 is driven into the conducting state and Q409 into the cut off state. As Q409 is driven into the cut off and its collector current ceases to flow, the potential between R440 and R441 is reduced and the base voltage of Q408 also is rapidly reduced from $+2\text{ V}$.

When Q408 has started conducting, its collector current flows through R448 and the forward current of D402 is reduced. The operating point of D402 moves to the low voltage region (point (A) as shown in Fig. 4—11), and its cathode voltage is varied stepwise in the positive polarity. Under this state, D402 is not driven into the high voltage region by applying the trigger pulse.

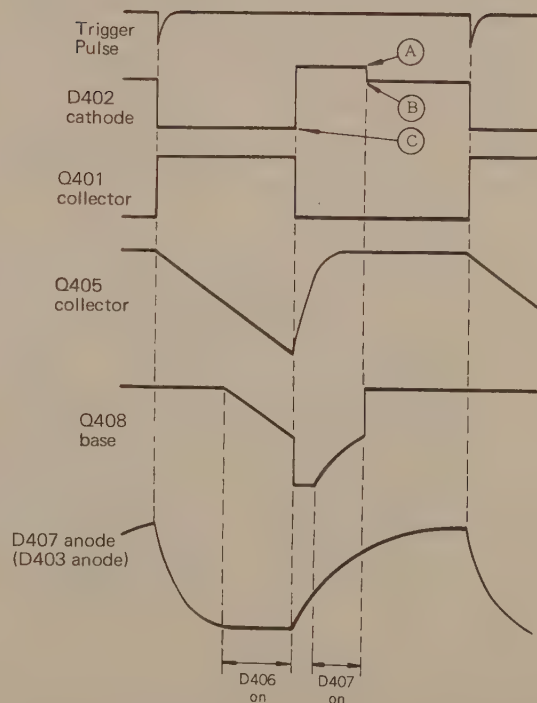
As the gate multivibrator is driven into the low voltage region, Q401 is driven into the cut off state and D405 into the conducting state. C413 is rapidly discharged, the gate voltage of Q404 falls, and the collector voltage of Q405 rises instantaneously to +12 V.

On the other hand, as Q401 is driven into the cut off state, the base voltage of Q402 varies stepwise in the negative polarity and D403 is driven into the cut off state and its anode voltage rises. However, due to the load capacitance of C414, the voltage change is not so sharp as that of collector of Q405. Actually, the voltage rises gradually as determined by the time constant of R435 and C414.

When the voltage has become higher than the base voltage of Q408, D407 and D484 is driven into the conducting state and the base voltage of Q408 also rises in conformity with the voltage variation of the anode circuit of D407 and D484. When the base voltage of Q408 has exceeded +2 V, Q408 is driven into the cut off state and Q409 into the conducting state, the voltage between R440 and R441 increases, the base voltage of Q408 increases rapidly, and D407 and D484 is driven into the cut off state. As Q408 is driven into the cut off state and the collector current ceases to flow, the forward current of D402 increases and the operating point is moved to the (B) point of the characteristic curve shown in Fig. 4-11. Thus, the initial state is restored. If the trigger pulse is applied under this state, the operating point of D402 jumps to the high voltage region.

The period in which the base voltage of Q408 increases from E to +2 V or the period during which Q408 is held in the conducting state is called "hold-off period." The hold-off period must be set sufficiently longer than the period in which the collector voltage of Q405 rises completely (the sweep return period). The hold-off period is

Figure 4-12 Waveforms in NORM Operation



adjustable by changing C414.

By the above operation, one cycle of sawtooth wave generation is completed. The sawtooth signal generated as above is fed to the horizontal amplifier. A timing chart of waveforms for the above operation is given in Fig. 4-12.

Auto Operation

When the AUTO or FULL AUTO button of SWEEP MODE selector on the front panel of the SS-4100 is pushed, the A sweep generator is set for the AUTO mode of operation. The sweep generator operates either in the triggered mode or free-run mode in accordance with existence or absence of the trigger pulse signal as was previously described in "AUTO CIRCUIT" of Sub-section "TRIGGER CIRCUIT."

When no trigger pulse signal is applied, the operation is as follows: Transistor Q308 is in the conducting state and generates the AUTO pulse signal which is applied through D408 to the A sweep generator. As the signal is applied, the operating point of gate multivibrator D402 is moved to the high voltage region and the cathode voltage of D402 is changed stepwise in the negative polarity and the sweep starts. Thus, when no trigger pulse signal is applied, the sweep operation is made in the free-run mode with the AUTO pulse signal generated by the oscillation of Q308.

When the negative pulse signal is applied, the operation is as follows: Transistor Q308 is in the cut off state and the current which flows in D402 is identical with that flows in the NORM mode of operation. Therefore, the sweep operation is made in the triggered mode.

Single Sweep Operation < SS-4100G only >

When the SINGLE selector of the SWEEP MODE selec-

tor is pressed and other controls are set for the NORM OPERATION and the RESET switch is pressed, the synchroscope is set in the READY state for the single sweep operation in which the sweep is driven only for once by the initial pulse of the trigger signal and remains undriven by subsequent pulses. The circuit operation for this single sweep mode is as below.

As was described in the "NORM OPERATION," when one sweep cycle is over, Q408 is in the "on" state, Q409 is in the "off" state, and D402 is in the low voltage region (point A) as indicated in Fig. 4-11). In this case, Q481 is "on" and neon lamp NE401 is "off."

If the SINGLE button of the SWEEP MODE selector is pressed in the above case, the cathode of D483 is connected to the -12 V supply and, therefore, D483 and D407 are "on" and D484 is "off." The base potential of D408 does not rise and it remains "on." Consequently, D402 also remains in the low voltage region (point A as shown in Fig. 4-11), and the circuit is not driven into the READY state. Although the base potential of Q481 slightly falls when the SINGLE button of the SWEEP MODE selector is pressed, the transistor remains in the "on" state.

When the RESET switch is pressed under the above state, Q481 which has been charged with a voltage divided with R485 and R489 is shorted, thereby producing a positive pulse. The positive pulse is applied through C482 and D482 to the base of Q408, driving this transistor into the "off" state. As a result, D402 is driven into the READY state (point B) as indicated in Fig. 4-11) as explained in the "NORM OPERATION." In this case the base potential of Q481 also falls and this transistor is driven into the "off" state. Consequently, a potential difference is produced across neon lamp NE401 and the lamp is turned on to indicate that the circuit is ready for the single sweep operation.

If a trigger signal is applied under the above READY state, a single cycle of sweep generating operation is performed as described in the "NORM OPERATION." When the sweep cycle is over, the sweep generator does not produce any further sweeps because R435 is connected to the -12 V supply through D483 and D407. Thus, sweep is displayed only once on the CRT screen. After the sweep cycle is over, Q408 is driven into the "on" state, thereby turning off neon lamp NE401.

SWEEP STOP Operation

When the SWEEP STOP button is pressed, the 12 V potential is applied to the cathode of gate multivibrator D402 through R406 and, hence, D402 is clamped at the low voltage range (point A shown in Fig. 4-11). Therefore, gate multivibrator D402 is not inverted when a sync pulse or auto pulse is applied. Thus, the sweep is completely stationary and the electron beam is displayed as a still spot on the CRT screen. (For spot intensity, refer to Section "Z AMPLIFIER.")

B SWEEP GENERATOR

The construction of the B sweep generator is as shown in Fig. 4-13. This generator operates when the A INT BY B button or DLY'D (B) button of HORIZ DISPLAY selector is pushed, and generates the following signals:

- (1) Sawtooth signal (sweep signal): This signal is amplified by the horizontal amplifier and fed to the horizontal deflection plates of the CRT.
- (2) Unblanking signal: This signal displays the required section of the trace and erases the return trace. This

signal is amplified by the Z-axis amplifier and applied to the deflection plates of the CRT. The operation is made either in the A INT BY B mode or DLY'D (B) mode.

The B sweep generator differs from the A sweep generator in that, while the latter generates a sweep signal by itself, the former generates a delayed sweep signal upon receiving the sweep signal of the A sweep generator through the delay pickoff circuit. When the MODE (PUSH TRIG) switch is in the OFF state, the sweep signal is generated at the instant the A sweep signal (sawtooth wave) has reached the set level. When the switch is in the ON state, the sawtooth signal is generated by the trigger pulse which is applied after the A sweep signal has reached the set level. However, if no trigger pulse is applied after the A sweep signal is over, no B sweep signal is generated. When the A sweep signal is over, the operation of the B sweep generator is unconditionally stopped even if it is in its midway of operation.

When the A button of the HORIZ DISPLAY switch is pushed, the +12 V supply is fed through S501 to R522. Therefore, gate multivibrator D506 remains in the low voltage region, the circuit is not inverted by the trigger signal, and no B sweep signal is generated.

Continuous Delay Operation

The continuous delay operation is as described below. This operation is obtained when the A INT BY B button or DLY'D (B) button of HORIZ DISPLAY selector is pushed and the B MODE (PUSH TRIG) button is set in the unpushed state.

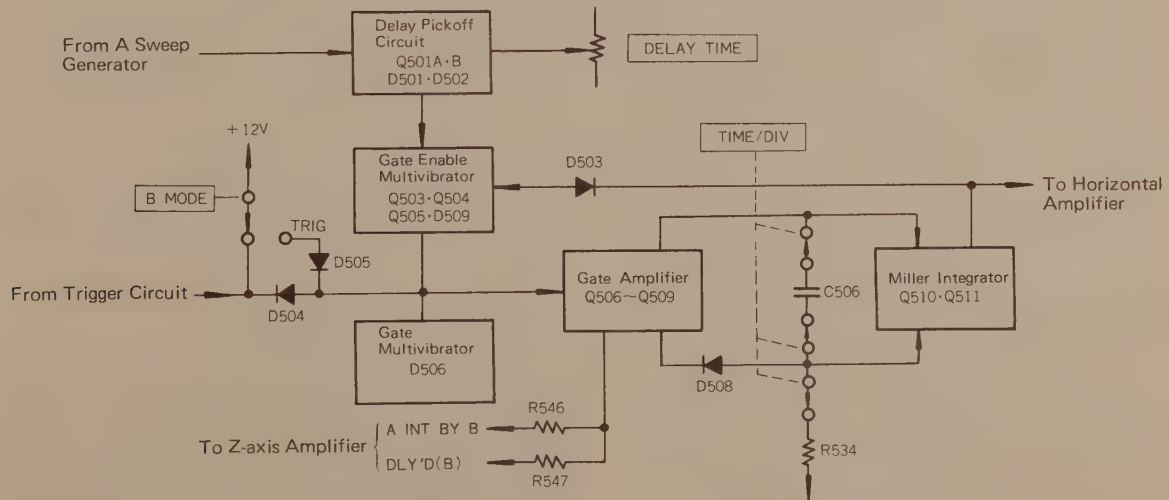
The state of the B sweep generator before the A sweep signal is applied to it is as described below. In this description, explanation of the gate amplifier and Miller integrator

shall be omitted because functions of these circuits before application of the A sweep signal are identical with those of the A sweep generator.

Transistors Q501A and Q501B of the delay pickoff circuit make up a comparator. When the A sweep signal is not applied, the base potential of Q501A is higher than

that of Q501B and the former is in the cut off state and the latter in the conducting state. D501 and D502 are used to protect Q501A and Q501B against reverse voltages. Since Q501A is in the cut off state, the gate enable multivibrator is in the OFF state as no power is supplied to its transistors Q503 and Q504. In this case the base

Figure 4-13 Block Diagram of B Sweep Generator



voltage of Q503 is held at approximately +4 V by resistors R509 and R510, and that of Q504 at approximately +2.7 V by resistors R508, R511 and R512.

Gate multivibrator D506 also is set for the low voltage region (point B) as shown in Fig. 4-11). Q506 is held in the cut off state and no sweep operation is made, and the output of the Miller integrator is held at +12 V. Consequently, D503 is in the cut off state.

Assuming that the A sweep signal is fed to the base of Q501A under the above state, the base voltage of Q501A falls linearly. When the voltage has fallen below the base voltage of Q501B which is set by DELAY TIME resistors R503 and R504, Q501B is driven into the cut off state and Q501A into the conducting state, and currents are fed to the emitters of Q503 and Q504. Since the base voltage of Q504 is lower than that of Q503, Q503 is in the cut off state and Q504 is in the conducting state, the current flows in D509 and its operating point moves into the high voltage region, and Q505 is driven into the conducting state and the sweep starts.

Since D503 is connected in the output circuit of the Miller integrator, D503 is driven into the conducting state when the collector voltage of A511 has fallen to approximately +4 V. Consequently, the base voltage of Q503 starts falling. When the voltage has fallen below approximately +2.7 V, Q503 is driven into the conducting state and Q504 into the cut off state and, since no current is fed to D509, its operating point moves into the low voltage region. Then, Q505 is driven into the cut off state, the operating point of D506 moves stepwise to the low voltage region, and the sweep stops. When the A sweep is over, Q501A is driven into the cut off state and Q503 also is driven into the cut off state since no current is supplied. By the above operation, one cycle of the B sweep is complete. If the B sweep ends before the B sweep is

complete, Q501A is driven into the cut off state, Q503 and Q504 also are cut off because no currents are supplied to them, Q505 is cut off, D506 is driven into the low voltage region, Q506 is cut off, and the B sweep is stopped in its midway.

Trigger Delay Operation

When the B MODE (PUSH TRIG) switch is pushed from the continuous delay setting, the operation is switched to the trigger delay mode. In this case the +12 V power is supplied through D502 to D505, driving the D505 into the conducting state and raising the cathode potential of D505. Therefore, even when Q505 is driven into the conducting state, the operating point does not jump to the high voltage region but remains in the ready-state point (point B as shown in Fig. 4-11).

If the negative pulse is applied under this state, D506 jumps to the high voltage region as it is driven through D504 and, consequently, Q506 is driven into the conducting state and the sweep starts. The other details of operation are identical with those of the continuous delay operation.

HORIZONTAL AMPLIFIER

A block diagram of the horizontal amplifier is shown in Fig. 4-14. This amplifier amplifies one of the below-mentioned two signals, as selected by the HORIZ DISPLAY selector, to a sufficiently high level to drive horizontally the electron beam of the CRT.

- (1) Sweep signal (sawtooth wave) of the A sweep generator — When the A button of A INT BY B button is pushed.

- (2) Sweep signal (sawtooth wave) of the B sweep generator — When DLY'D (B) button is pushed.

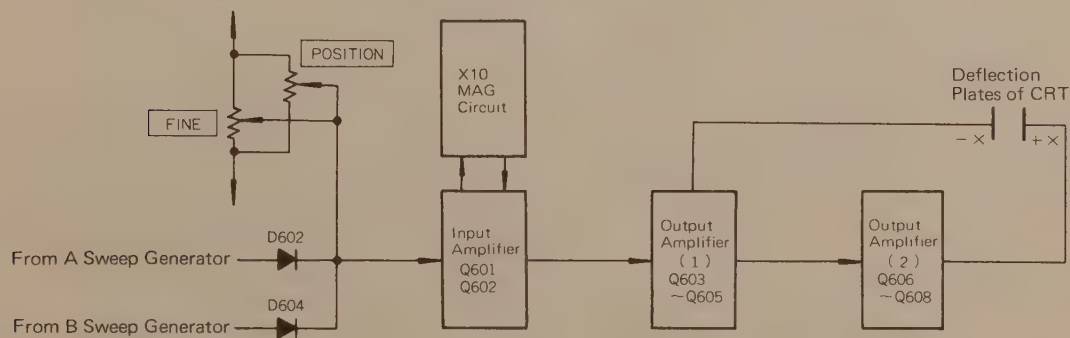
Input Amplifier

Either the A or B sweep signal is selected by switching diodes D601, D602, D603 and D604. The selected signal is fed to the input amplifier. The input amplifier, with its emitter follower Q601 and Q602, makes up a parallel feedback circuit. The signal is fed back from the collector of Q602 to the base of Q601 through a feedback resistor circuit, and the x10 magnification operation is accomplished by varying the feedback resistance.

When the PULL x10 button is pulled, the current which has been flowing from the +12 V supply to coil RL601 is cut off, switch RL601 is opened, the feedback rate from Q602 to Q601 is reduced, and the x10 magnification is accomplished. POSITION control R613 and FINE control R615 are used to vary the current which flows into the parallel feedback circuit, for vertical positioning of the trace on the CRT screen.

Potentiometers R610 and R622 are used to control the magnitude of the sweep signal fed from the sweep generator. Potentiometer R624 is used to make up for the sweep start point deviation which could be produced when the PULL x10 switch is pulled after setting the sweep start

Figure 4-14 Block Diagram of Horizontal Amplifier



point at the horizontal scale center of the graticule.

Output Amplifier (1)

The output amplifier (1), with its Q603, Q604 and Q605, make up a parallel feedback amplifier. It amplifies the output of the input amplifier, with a gain determined by R629/R626. D606, D607, Q605 and R630 are used to maintain constant the currents of Q603 and Q604, irrespective of the amplitude of the sawtooth output signal. The output amplifier with the construction as above, amplifies the high speed sawtooth signal stably and with a good regulation against the AC line voltage variation. The signal is amplified to a sufficient level and, then, it is applied to one pin (-X) of the CRT.

Output Amplifier (2)

The output amplifier (2), with its Q606, Q607 and A608, makes up a parallel feedback circuit. This amplifier inverts the polarity of the output of output amplifier (1). The gain of this output amplifier is approximately 1 as determined by the ratio of R642/R640. The output of this amplifier is applied to the other horizontal deflection pin (+X) of the CRT. The remaining details of operation of this amplifier are almost identical with those of output amplifier (1).

Z AXIS AMPLIFIER

The construction of this amplifier is as shown in Fig. 4-15. This amplifier handles the following four signals to control the trace intensity in accordance with settings of controls.

- (1) Unblanking signal used to brighten the required trace and erase the return trace.
- (2) Chop unblanking signal used to erase transients in CHOP mode of operation.
- (3) External intensity modulation signal which is externally applied to Z AXIS INPUT terminal.
- (4) Spot intensity control signal used to control the spot brightness in SWEEP STOP state.

Switching Circuit

The switching circuit, consisting of diodes D705 — D710, selects the required signal to be fed to the feedback amplifier.

For the SWEEP STOP mode, the +12 V power is supplied through S410 to R718, the anode voltage of D706 is approximately +9.5 V, the anode voltage of D705 is approximately +0.7 V as suppressed by the base of Q704 and, therefore, D706 is in the conducting state and D705 is in the cut off state. Therefore, irrespective of the signal fed from the sawtooth generator, a voltage controlled by BRIGHT ADJ R714 is applied to the feedback amplifier.

For the A sweep mode, the -12 V power is applied to the anode of D706 through R717 and this anode voltage is lower than the D705 anode voltage which is approximately +0.7 V. Therefore, D706 is in the cut off state and D705 is in the conducting state. Since the +12 V power is supplied through S501 to R723 and R726, D709 and D708 are driven into the cut off state, and the unblanking signal from the A sweep generator alone is applied to the feedback amplifier through D705.

For the A INT BY B mode, the +12 V power is supplied through S501 through R723 and, therefore, D709 is in the conducting state and D708 is in the cut off state. On the other hand, since the -12 V power is supplied through

R725 and R726 to the anode of D710, D710 is in the cut off state and D707 is in the conducting state. Consequently, the unblanking signal from the A sweep generator and the signal received through R546 from the B sweep generator are applied simultaneously (being superimposed) to the feedback amplifier.

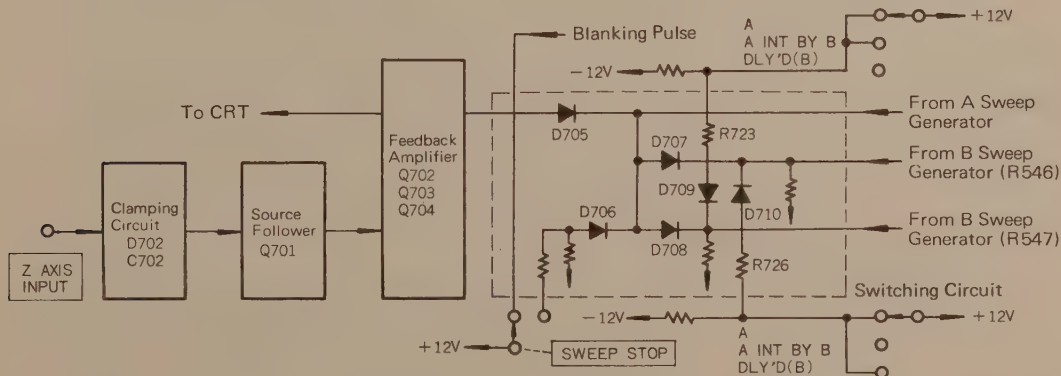
For the DLY'D (B) mode, D708 and D710 are in the conducting state and D707 and D709 are in the cut off state. Consequently, the blanking signal from the A sweep generator and the signal received through resistor R547 from the B sweep generator are applied simultaneously (being superimposed) to the feedback amplifier. For the

CHOP mode, the chop blanking pulse signal is directly applied to the feedback amplifier.

External Intensity Modulation

The signal applied to the Z AXIS INPUT terminal is clamped by the clamping circuit consisting of C702 and D702, so that the maximum value of the signal is made zero volt. Then, the signal is applied through source follower Q702 to the feedback amplifier. D701 and D711 are used to protect Q701 against abnormally large input voltage.

Figure 4-15 Functional Diagram of Z-axis Amplifier



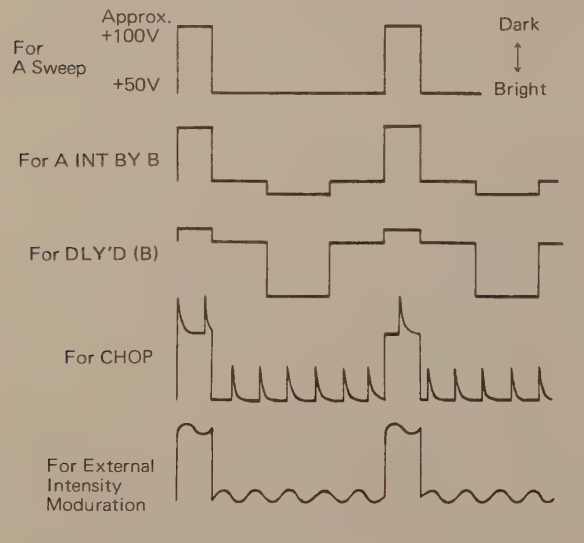
Feedback Amplifier

The signals mentioned in the above are amplified by the feedback amplifier consisting of Q703, Q704, and feedback resistor R709. In the SWEEP STOP mode of operation, the current which flows in R709 is determined by setting of BRIGHT ADJ R714 which should be so adjusted that the output voltage is made approximately 50 V or the displayed spot is made brightest. In the other modes than SWEEP STOP, the current is determined by setting of

BRIGHT ADJ R716 which should be so adjusted that the minimum output is made approximately +50 V. Q702, together with D703, D704 and D708, makes up a constant current circuit in order to feed constant currents to Q703 and Q704 irrespective of amplitude of the output waveform.

Output waveforms amplified as above are illustrated in Fig. 4-16. These waveforms are applied to the deflection plate (No. 12) of the CRT in order to control the brightness of the trace displayed on the CRT.

Figure 4-16 Output Waveforms of Z-axis Amplifier



CRT CIRCUIT

A block diagram of the CRT circuit is shown in Fig. 4-17. This circuit produces the high voltage required to emit and accelerate the electron beam in the CRT. The high voltage is produced by converting the unregulated low voltage power (approx. 20 V) into a sine wave voltage of approximately 30 kHz and boosting this voltage by high voltage transformer T801 and by rectifying the high frequency power in double-voltage rectification and half-wave rectification modes by the high voltage rectifier and cathode rectifier.

High Voltage Oscillator

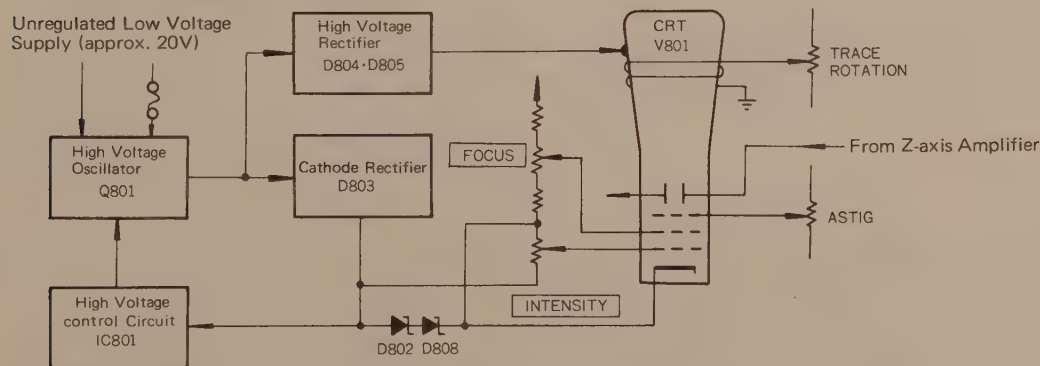
The high voltage oscillator circuit consists of Q801, the primary winding of T801, and C803. When the POWER switch of the SS-4100 is turned on, the current is fed into the collector coil of the primary circuit of T801. Consequently, an e.m.f. is produced in the base coil of the primary circuit of T801, the base potential of Q801 rises in

the positive polarity, and the collector current is increased further. During the above operation, C803 is charged in negative potential.

The collector current flow until the saturated state is reached. When the saturation is reached, the e.m.f. in the base coil collapses. Now the base potential of Q801 falls due to C803, its collector current is reduced and the

collector voltage rises. As a result, an e.m.f. in the reverse polarity of the above-mentioned e.m.f. is produced in the base coil, C803 is charged in the positive polarity, and Q803 will soon be driven into the conducting state. The high voltage oscillator repeats the above cycle at a rate of approximately 30 kHz.

Figure 4-17 Block Diagram of CRT Circuit



Cathode Rectifier

The cathode rectifier provides a supply power of approximately -1450 V for the CRT cathode. The e.m.f. between terminals Nos. 5 and 6 of high voltage transformer T801 is half-wave rectified by D803, and is fed through Zener diodes D802 and 808 to the CRT cathode. It also is voltage-divided by R812 and is applied to the control grid of the CRT. Thus, INTENSITY R812 controls the trace intensity by controlling the bias voltage between cathode and control grid. FOCUS R815 and ASTIG R818 are used to obtain a sharp image of the displayed trace or spot.

High Voltage Rectifier

The high voltage rectifier supplies an electron beam acceleration voltage of approximately +5 V. This voltage is produced by rectifying the voltage between terminals Nos. 5 and 7 of high voltage transformer T801 using a voltage doubler consisting of D804, D508, C805 and D806.

High Voltage Control Circuit

This circuit maintains constant the secondary voltage by feeding back a part of the secondary voltage to the high voltage oscillator to control its oscillation amplitude.

Let us assume that the cathode voltage has been dropped due to load change. This variation of the cathode voltage is fed to No. 2 terminal of IC801 and the base current of Q801 is increased. Consequently, the collector current of Q801 increases and the oscillation amplitude is enlarged. Thus, the cathode potential is maintained constant. H.V. ADJ R802 is used to adjust the oscillation amplitude.

POWER SUPPLY

A block diagram of the power supply is shown in Fig. 4-18. The power supply provides three regulated DC powers, two non-regulated DC powers, and 6.3 V AC powers for the functional circuits of the SS-4100/SS-4100G. The regulated powers are of low ripple rates and are incorporated with protective circuits against short-circuiting to the ground.

Power Supply Input

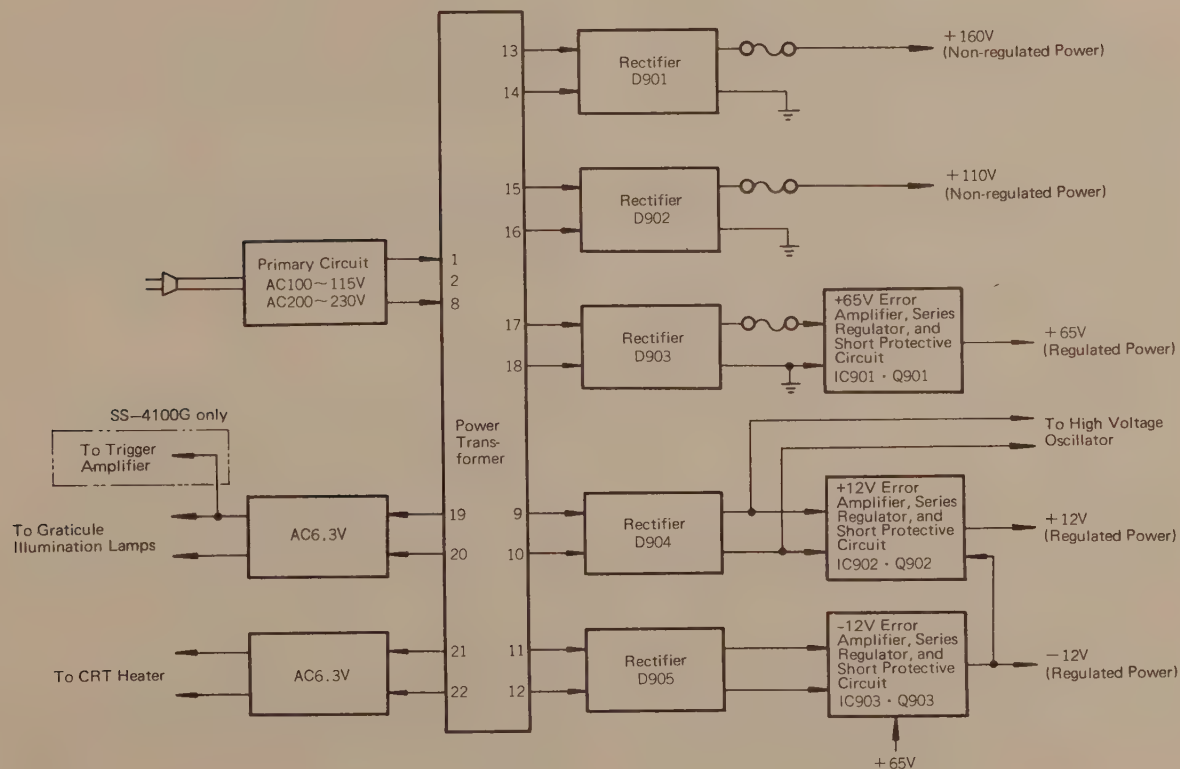
The AC line power is supplied through fuse F900, power switch S901 (pushbutton switch), switch S902 (100 V - 115 V selection), to terminals 1 and 2, 3, or 4, or to terminals 1 and 6, 7, or 8 of the primary winding of power transformer T901.

When the power input circuit is completely closed, neon lamp NE901 lights (as its power is supplied through resistor R902) to indicate that the SS-4100/SS-4100G is in its operating state. The relationship between AC supply voltage and terminals of the power transformer is shown in Table 4-1.

Table 4-1

AC supply voltage	Terminals of T901
100 V	1 - 2
110 V	1 - 3
115 V	1 - 4
200 V	1 - 6 (connect 2 with 5)
220 V	1 - 7 (connect 3 with 5)
230 V	1 - 8 (connect 4 with 5)

Figure 4-18 Block Diagram of Power Supply



-12 V Power Supply

The -12 V power supply is used as the voltage reference for other power supplies. The output of terminals 11 and 12 of the secondary circuit of T901 is rectified by rectifier D905 and is filtered by capacitors C906 and C907. IC903 has the error amplifier, series regulator, and short protective circuit. The filtered voltage is applied to the -12 V series regulator consisting of Q903 and IC903, in order to be voltage-regulated.

The series regulator is a variable resistor (dynamic resistor) of which output current is controllable. The series regulator is controlled by the error amplifier.

The output of the -12 V power supply is maintained constant at -12 V irrespective of load variation, by feeding a part of its output through the error amplifier to the series regulator. ADJ R033 is for determination of the reference voltage of the error amplifier or for calibration of the output of the -12 V power supply. The short protective circuit is used to protect the series regulator when the output of the -12 V supply is erroneously short-circuited to the ground.

+12 V Power Supply

The voltage rectified by rectifier D904 is filtered by capacitors C904 and C905 and, then, it is supplied to the +12 V series regulator. On the other hand, the filtered output is fed to the high voltage oscillator of the CRT circuit.

The -12 V supply voltage is used as the reference for the +12 V supply power. A part of the +12 V supply voltage as divided with resistors R925, R926, and R927 is compared with a part of the -12 V supply voltage by the error amplifier of IC902. The voltage regulating operation of this

power supply is identical with that of the -12 V power supply.

+65 V Power Supply

The basic operation of the +65 V power supply is identical with that of the +12 V power supply.

+110 V Power Supply and +160 V Power Supply

The voltage rectified by rectifier D902 is filtered by the filter circuit consisting of R904 and C902, obtaining a non-regulated +110 V supply voltage. In a similar manner, the non-regulated +160 V supply power is obtained through rectifier D901.

6.3 V AC Powers

The 6.3 V AC power obtained between terminals 21 and 22 of the secondary circuit of the power transformer is supplied to the heater of the CRT. This power supply circuit is specially-treated for high voltage insulation.

The other 6.3 V power obtained between terminals 19 and 20 is used for lighting the graticule illumination lamps PL901 and PL902. Regarding the SS-4100G, the 6.3 V power obtained between terminals 19 and 20 is also applied as a line frequency trigger signal to the trigger generator.

CALIBRATOR

A block diagram of the calibrator is shown in Fig. 4-19. The calibrator generates a pulse signal with a high frequency accuracy.

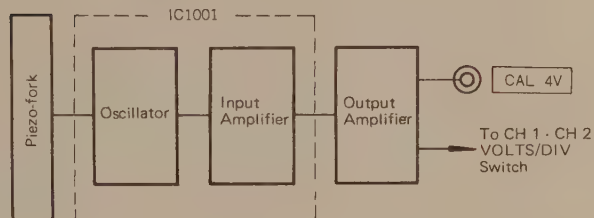
Oscillator

The oscillator employs a piezo-fork which provides a highly stable inherent frequency. A positive feedback is supplied from the amplifier of IC1001 to the piezo-fork to oscillate a sine wave which then is converted into a pulse wave (square wave) by the shaping circuit of IC1001.

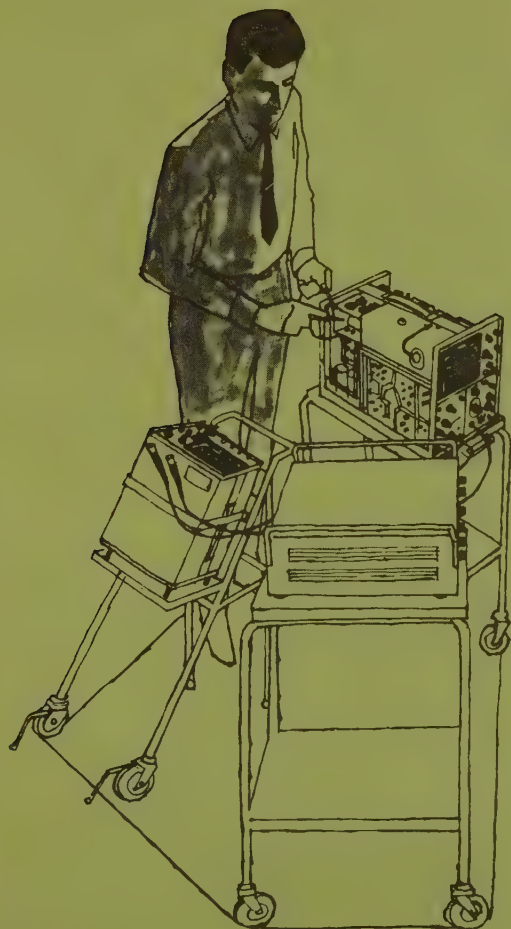
Output Voltage Divider

The pulse output voltage is divided by a voltage divider consisting of resistors and then is fed to CAL 4 V output connector. At the same time, through another voltage divider, the pulse signal is fed to the VOLTS/DIV switches of both channels.

Figure 4-19 Block Diagram of Calibrator



MEMO



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SECTION MAINTENANCE

In this section, maintenance procedures which will ensure optimum operation of the SS-4100/SS-4100G for a long period will be described. If testing or replacement of parts is required, refer to CIRCUIT LOCATION DIAGRAMS of SECTION 8.

In addition to proper maintenance, a thorough understanding of instrument performance and proper operation (SECTION 2, PRE-START OPERATION is especially important) are essential to ensure optimum performance of the instrument.

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PREVENTIVE MAINTENANCE

Maintenance procedures listed herein outline periodic tests which insure optimum operating efficiency and indicate preventive maintenance measures when required.

Cleaning

The instrument should be kept clean at all times, although dirt may differ with the place where the instrument is used. Dust accumulating in the instrument affects the radiation of heat and may cause overheating and the subsequent failure of parts. Foreign substances on switch contacts or connectors result in poor contact and on printed circuit boards, it may cause arcing in damp climates or seasons. Suitable cleaning agents are listed in Table 5—1. Those agents indicated as unsuitable must not be used.

Table 5—1

Suitable cleaning agents	Alcohol, gasoline, and xylene
Unsuitable	Acetone, methyl-ethyl-ketone, ether, lacquer thinner, and chemicals containing ketone series solvents.

Front Panel Cover

Ordinary dirt on the front panel cover can be removed by washing the cover with a mild detergent. When grease or oil is present, use a soft cloth and one of the preferred cleaning agents listed in Table 5—1.

Front Panel and Knobs

Clean the front panel and knobs with a soft cloth and one of the preferred agents listed in Table 5—1. Use of alcohol may result in slight discoloring of the panel. When mild detergent is used be sure to wipe off the remaining detergent on the panel or knobs after cleaning, with a soft damp cloth.

Dirt in Instrument

The best way to remove dirt or dust inside the instrument is to blow it out with air under pressure. Use of a soft brush in conjunction with the air will aid in the cleaning.

Dirt on Smoked Filter and Graticule

In a long time the polarized filter and graticule also will become dirty. Dust or fingerprints can be removed by wiping the surface with a soft cloth. Stains or sticking dirt can be removed with alcohol.

When The Instrument is to be Left Idle

When the instrument is not going to be used for a certain period, disconnect the probe and adaptor from the panel and cover the instrument with the protective dust cover. Store the accessories in the accessory box and place the instrument in a dry place.

Visual Inspection

A simple visual check of the inside of the instrument will sometimes reveal various defects, such as charred resistors, defective contacts, or broken circuit boards. Immediate repair of these minor defects will prevent more serious troubles.

Periodical Inspection

The SS-4100/SS-4100G must be calibrated periodically (once in every six months would be appropriate) in order that an accurate instrument performance is ensured.

TROUBLESHOOTING

A troubleshooting procedures will be described here. A thorough understanding of the overall system and circuit operation of this instrument will prove to be a valuable aid in troubleshooting. For this purpose refer to SECTION 4, CIRCUIT DESCRIPTION.

Troubleshooting References

Schematic Circuit Diagrams

Schematic circuit diagrams are provided for individual blocks shown in Fig. 4-1 "Basic block diagram." For symbols used in the schematic circuit diagrams, refer to SECTION 8 "DIAGRAMS."

Circuit Voltages and Waveforms

Normal voltages and waveforms of required points of the circuit are shown in each schematic circuit diagram. Note that voltages and waveforms vary by setting of controls and therefore the circuit must be tested under the measuring conditions specified in each schematic circuit diagram.

Circuit Location Diagrams

Locations of individual circuits (printed boards) of SS-4100/SS-4100G are shown in circuit location diagrams (Figs. 8-1 to 8-3) of SECTION 8 "DIAGRAMS." In servicing the synchroscope, locations of required circuits can be easily found by referring to these diagrams (photos).

Locations of Components

Circuit components mounted on circuit boards can be identified by the parts numbers printed on the circuit boards.

Wiring Color Code

Wires used in SS-4100/SS-4100G are color coded being classified according to their functions. Two-colored wires are for the power supply circuit, and solid color wires are used for general circuit wiring. The color code of wires is shown in Tables 5-2 and 5-3. Table 5-3 shows a typical use of wires, and some wires in the synchroscope may deviate from the code. The code is not applicable to shielded wires.

Table 5-2 Color code of power supply wires (Two colored)

Low voltage source	Base color	Stripe color
-12 V	White	Black
+12 V	White	Red
+65 V	White	Blue
+110 V	White	Brown

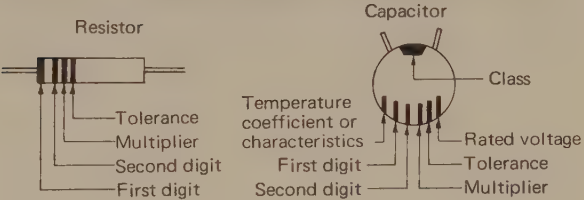
Table 5-3 Color code of general wiring (Solid color)

Circuit	Color
Collector or drain wires	Red
Base or gate wires	Yellow
Emitter or source wires	Blue
Positive voltage wires	Brown
Negative voltage wires	Purple or gray
Others (signal line, etc.)	White
Ground wires	Black

Resistor and Capacitor Color Code

The resistors and capacitors used in the circuits are color coded as shown in Fig. 5-1.

Figure 5-1. Resistor and capacitor color code



Color	Resistance or capacitance value		Tolerance for capacitance (%)	Tolerance for capacitance (%)		Rated voltage of capacitor
	1st and 2nd significant digits	Multiplier		10 pF or more	10 pF or less	
Black	0	1	—	±20.0	±2.0	—
Brown	1	10	± 1	± 1.0	—	—
Red	2	10 ²	± 2	± 2.0	—	250 V
Orange	3	10 ³	—	± 2.5	—	300 V
Yellow	4	10 ⁴	—	—	—	—
Green	5	10 ⁵	—	± 5.0	±0.5	500 V
Blue	6	10 ⁶	—	+100 (0)	—	—
Purple	7	10 ⁷	—	—	—	—
Gray	8	10 ⁸	—	±10.0	±0.25	—
White	9	10 ⁹	—	—	±1.0	1000 V
Gold	—	10 ⁻¹	± 5	—	—	—
Silver	—	10 ⁻²	±10	—	—	—
Not colored	—	—	±20	—	—	—

Transistors and Diodes

Of the transistors and diodes used in the SS-4100/SS-4100G, their types and electrode symbols are as shown in Tables 5-4 and 5-5, respectively.

Table 5-4 Types and electrode symbols of transistors

Types of transistors	Electrode symbols of transistors
2 SC857①	
2 SC1216 2 N 4034 2 SC 154	
MK10-2-C MK10-2-D	
KH5199	
Power transistors 2SC685A, 2SD93	
MJE1100	

Table 5-5 Types and electrode symbols of diodes

Type of diodes	Electrode symbols of diodes
1 S 953 1 S 955 RD type HW type 1 S1690N	
Tunnel diode 1 S1761	
HF-SD-1	
VF5-7 X VF5-12X	
1 S2191	
DAP-4	

Measuring Instruments Required for Troubleshooting

The following instruments are required for troubleshooting.

- (1) Multimeter

Input impedance:	10 M Ω
Voltage range:	Normal range 0 ~ 300 V, should be cable of measuring 2 kV by changing test cords.
Resistance range:	0 ~ 20 M Ω
- (2) Transistor curve tracer
- (3) Test synchroscope

Frequency range:	DC — 20 MHz
Sensitivity:	10 mV/cm

For accurate performance calibration as would be the case when linearity or frequency is abnormal, measuring instruments and tools as mentioned in INSTRUMENTS REQUIRED FOR OPERATION CHECK AND CALIBRATION in SECTION 6 are required.

Prior to Troubleshooting

First, it should be determined whether the instrument is actually defective, or other external conditions are responsible for the trouble indications. For example, when the power source voltage exceeds the allowable operating range, or external noise is induced in the test set-up, the display will become irregular. But the instrument is not abnormal.

When the display at a certain sweep rate is somewhat irregular and it is difficult to determine whether the instrument is defective, it is advisable to observe another type of signal and see if the same irregularity occurs.

Troubleshooting Procedure and Sequence

The following procedures and sequence of troubleshooting will help to save time.

- (1) Before removing the covers from the instrument, verify all control functions described in SECTION 2, OPERATING PROCEDURE. This should aid in localizing the defective portion to a particular circuit such as the low voltage power supply, CH 1 preamplifier, CH 2 preamplifier, trigger generator and so forth.
Table 5—6 shows an effective trouble localization chart. If the instrument operates as mentioned in the vertical column of the chart (if the answer is yes), it is certain that the instrument operation is normal to that row of the chart. If the instrument does not operate as mentioned in the vertical column (if the answer is no), the cause of the trouble lies in the left-hand column of that row.
- (2) Next, remove the cover on the side of the instrument which contains the suspicious circuit, and visually check components, wires, and the copper foil of the PC board for irregularities such as charred wires or resistors, defective contacts or broken wires. Various causes of trouble may be detected by a thorough visual inspection.
- (3) Check the low and high voltage supplies. A trouble in the low voltage power supply has considerable influence on other circuits. Abnormal voltage from power supplies must be corrected.
- (4) Next, use a multi-meter or test synchroscope to check the operation of individual circuits referring to the circuit diagrams in the last section, and localize the defective circuit.

- (5) Check the characteristics of suspicious active elements (transistors, diodes, or IC's) and passive parts

(resistors or capacitors, etc.). Replace any defective part(s). Two or more parts may be defective.

Table 5-6 Troubleshooting chart

First, set the panel controls of the SS-4100 as follows:

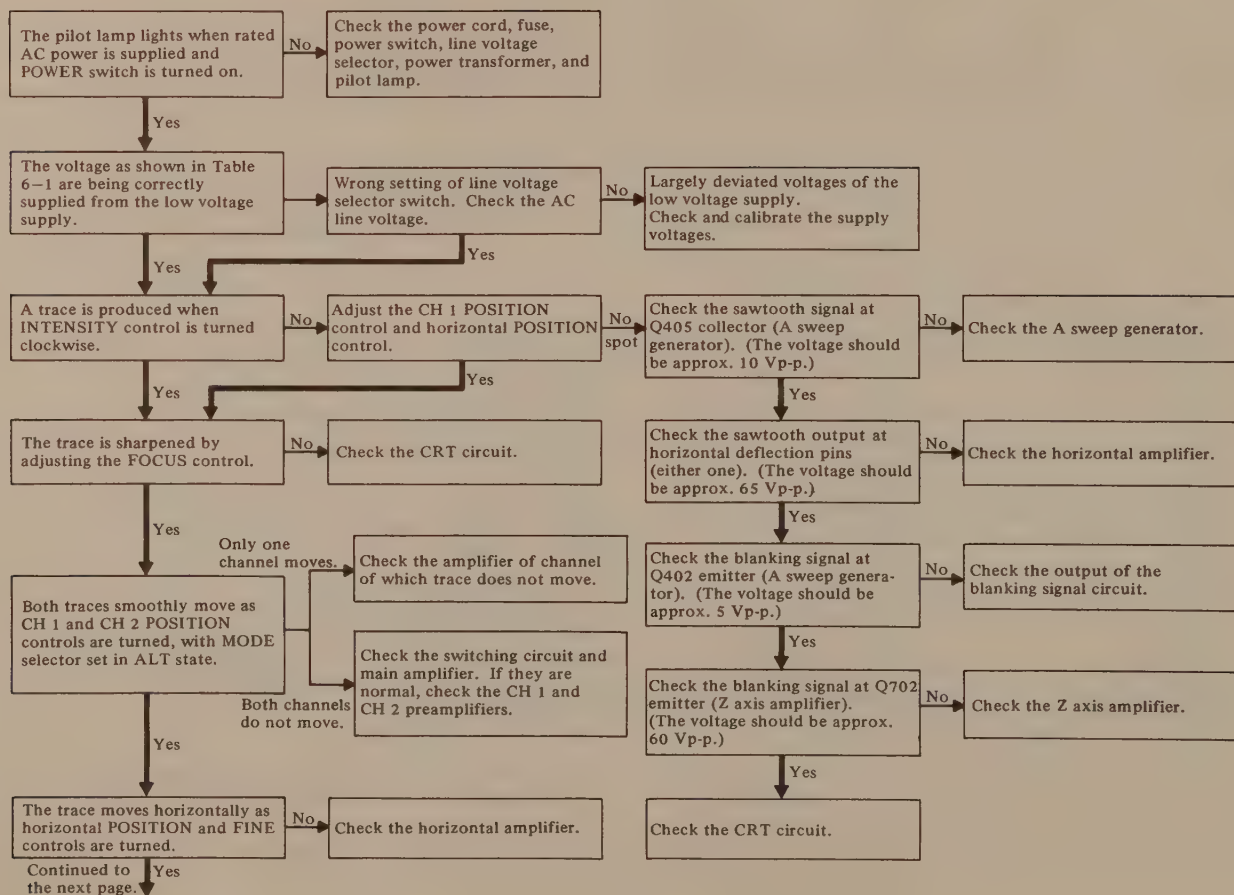
— FRONT PANEL —

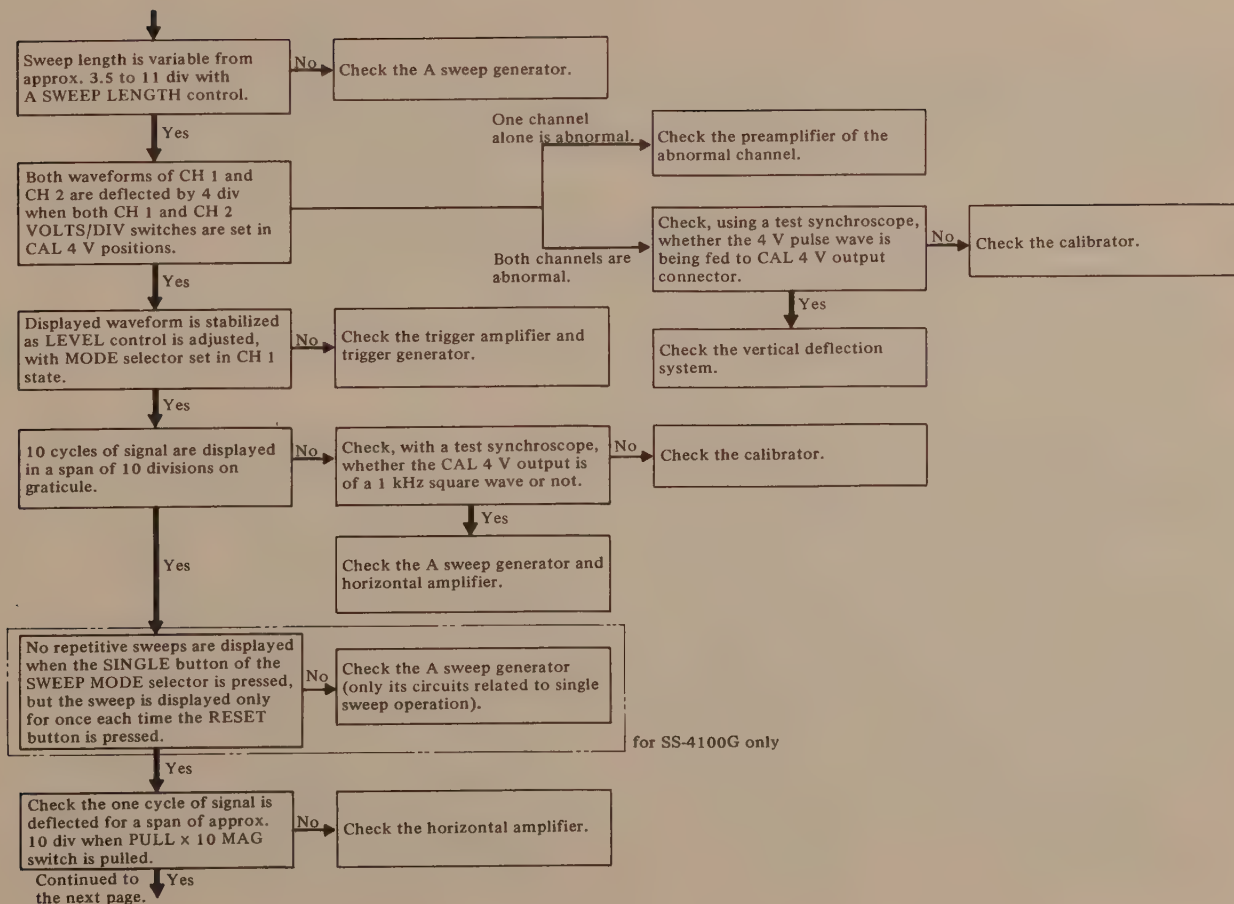
POWER:	Off
INTENSITY:	Fully counterclockwise
FOCUS:	Mid-position
AC-GND-DC (CH 1, CH 2):	GND
VOLTS/DIV (CH 1, CH 2):	10 mV
VARIABLE <SS-4100G only>:	CALIB
POSITION (vertical):	Mid-position
MODE:	CH 1
CH 2 POLARITY:	Un-pushed state
SOURCE:	INT CH 1
SWEEP MODE:	AUTO
COUPLING:	AC
HORIZ DISPLAY:	A
B MODE (PUSH TRIG):	Un-pushed state
A TIME/DIV:	1 msec
A VARIABLE <SS-4100G only>:	CALIB

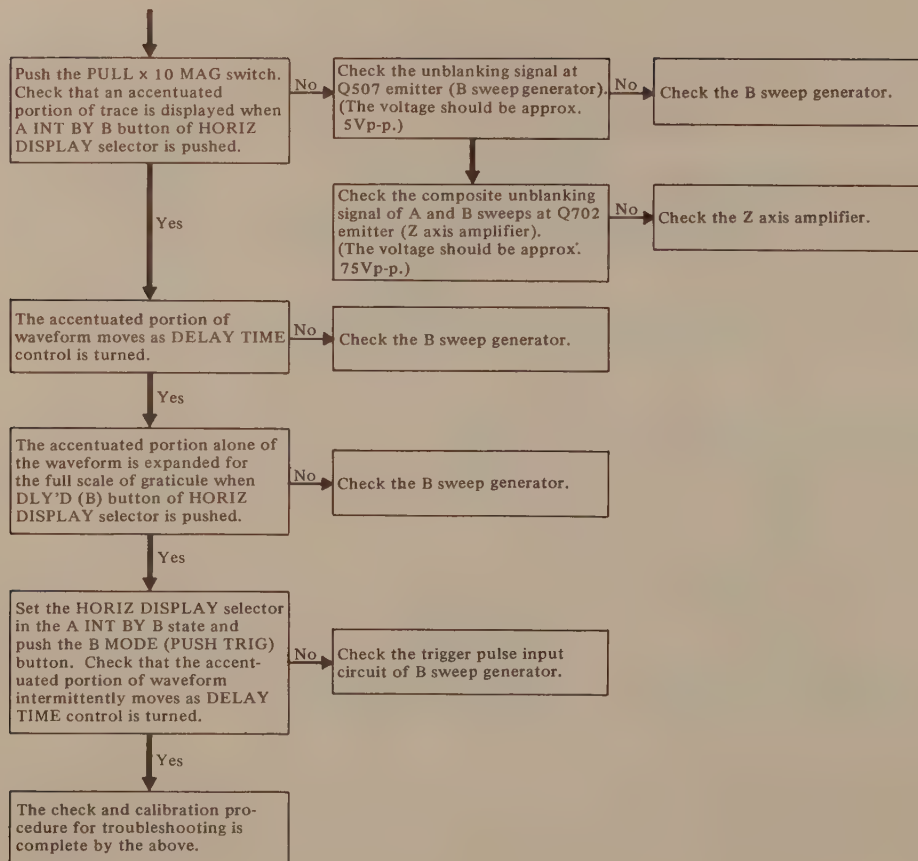
B TIME/DIV:	0.1 msec
SWEEP STOP:	Off
(right side panel for the SS-4100G)	
(PUSH+ SLOPE) LEVEL:	Push, mid-position
(PUSH- SLOPE) LEVEL:	Push, mid-position
(PULL x 10 MAG) FINE:	Push, mid-position
POSITION (horizontal):	Mid-position
DELAY TIME:	Fully counterclockwise

— RIGHT SIDE PANEL —

A SWEEP TIME:	Fully clockwise
SCALE ILLUM:	Appropriate position
EXT TRIG SELECTOR:	NORM
<SS-4100 only>	
TRIG SELECTOR:	EXT
<SS-4100G only>	







PARTS REPLACEMENT

The procedure and precautions for removing panel covers and parts in order to perform visual checking of circuits or defective components will be described here. Prior to removing a component, ensure that the power cord is disconnected from the AC source line. Pay special attention in handling the high voltage circuit.

Removal of Panel Covers

The top cover can be removed by removing its 10 screws; the bottom cover can be removed by removing its 6 screws.

Replacement of Transistors and Diodes

Quality transistors and diodes must be used for replacement. Specially selected transistors are used in major circuits of this instrument in order to ensure the performance characteristics described in SECTION 1. These transistors are listed in Table 5-7.

Care must be exercised in soldering semiconductors since they are not heat resistant. Hold the lead wire with pincers on the semiconductor side in order to intercept heat from

being conducted to the semiconductor, and apply the soldering iron a very short period. Note also that copper foil may come off the printed board if the soldering iron is applied for a long period to unsolder a component from the board.

Replacement of Power Transistor

To install a power transistor on a chassis, a mica insulator must be placed between transistor and chassis. Also, to promote heat dissipation, silicone grease must be applied on both surfaces of the mica insulator.

Replacement of IC

The IC is connected to the printed board with a number of leads which cannot be disconnected at one time unless a special soldering iron designed specifically for this purpose is used. Therefore, in the field where such special tools are unavailable, it is recommendable to cut the leads at their roots close to the IC and then disconnect the leads one by one using a conventional soldering iron.

IC's used in the SS-4100/SS-4100G have either 10 leads or 14 leads. These leads are numbered from No. 1 to No. 10 or No. 14, with the indented section of the corner as reference as shown in Fig. 5-2 (a). Of some IC's however, some leads have been omitted. Note that such unused electrodes (without leads) also have been counted in numbering the leads. In mounting an IC on a printed board, align the indented section of the corner with the marking on the printed board as shown in Fig. 5-2 (b).

All IC's used in the SS-4100/SS-4100G have been specifically designed and manufactured by IWATSU. They cannot be replaced with conventional IC's of other make.

Table 5-7 Specially-selected transistors

Circuit	Circuit symbols (and types) of specially-selected transistors
Vertical preamplifiers	Q102A, B (KH5199) Q103A, B (KH5199)

Replacement of Resistors and Capacitors

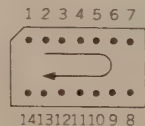
Passive elements (resistors and capacitors) used in the SS-4100/SS-4100G are also of specially-selected ones, and should be replaced with sufficiently quality ones. Burnt resistors or shorted capacitors may result from shortcircuiting or serious deterioration of transistors or diodes. Prior to replacing the defective passive element, check the cause of the trouble and remedy it.

Fuse Replacement

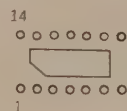
The AC line fuses are located on the rear panel, the low voltage power supply fuses on the bottom printed board, and the CRT circuit fuse at the rear within the instrument housing. These fuses are listed in Table 5—8.

If these fuses blew, check its cause correctly, repair the wrong parts or circuits, and exchange the blown fuses with prescribed new ones. The use of new fuses which are not prescribed may cause dangerous trouble; therefore, such use is prohibited positively.

Figure 5—2 IC Lead Identification and Printed Board Marking



(a) IC Lead Identification



(b) Printed Board Marking

Table 5—8 Fuses

Circuit symbol	Fuse type	Function	Location of fuse holder
F900	1 A, slowblow	For 100 V AC operation	Rear panel
	0.5 A, slowblow	For 200 V AC operation	Rear panel
F901	0.25 A	+160 V	Bottom printed board
F902	0.25 A	+110 V	Bottom printed board
F903	0.25 A	+65 V	Bottom printed board
F801	1 A	CRT circuit	At the rear within the set

Removal of Printed Boards

To remove a printed board, disconnect its wiring pins, undo its clamping-screws, and then disconnect the board from the connector. To put back the printed board, its wiring pins must be correctly inserted in the original positions. If they are erroneously inserted, the printed circuit will not correctly operate and permanent damage may be caused to semiconductors, resistors or other circuit elements.

CRT Replacement

Handle the CRT with extremem care as excessive force or shock may cause it to break or crack. If the deflection plate pins or electrode pins are bent, it may cause the glass

sealant around the pins to crack. Remove the CRT in the following sequence.

- (1) Remove both top and bottom panels and the rear CRT socket cover.
- (2) Remove the connectors from the deflection plate pins on the CRT neck and the anode cap at the upper front.
- (3) Remove the CRT socket at the back of the instrument.
- (4) Remove the four clamping-nuts (style-nuts) of the bezel. Remove the bezel, filter, and CRT protection paper.
- (5) After ensuring the above procedure is complete, push out the CRT to the front side of the instrument.

To re-install the CRT, follow the above procedure in the reverse sequence excluding the following procedure: To re-connect the deflection electrode pin connectors, the bottom printed board is required to be removed. After the printed board has been removed for this purpose, re-install it correctly in the original state.

After the CRT has been replaced, the instrument must be re-calibrated since pattern distortion and parallelism between trace line and graticule scale line differ according to individual CRT. (For the re-calibration, refer to Check and Calibration of Pattern Distortion or Parallelism of Vertical and Horizontal Trace with Respect to the Graticule

of SECTION 6.)

Replacement of high Voltage Oscillation Transformer

Prior to replacing the high voltage oscillation transformer which generates the high voltage for the CRT, turn off the power switch and disconnect the power cord from the AC line. Note that the CRT circuit remains charged with the high voltage for a substantial period after the power switch has been turned off. To replace the transformer, proceed as follows:

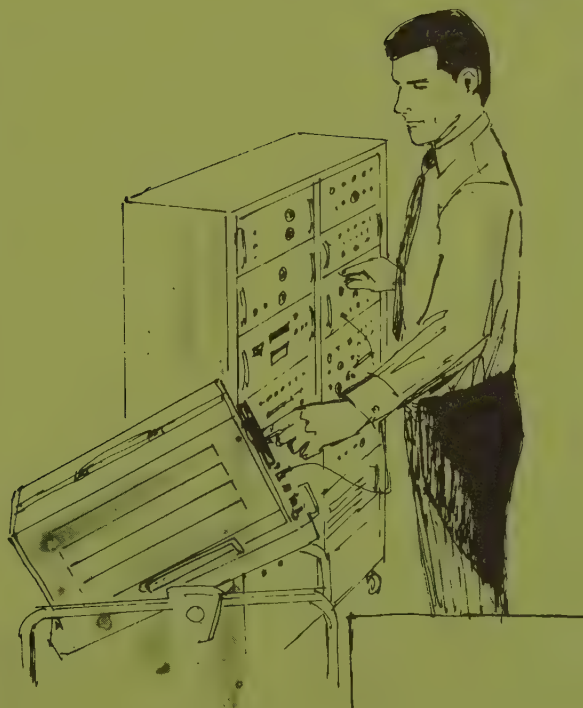
- (1) Remove the top cover.
- (2) Remove the high voltage cover (located in an upper position) after removing its four clamping-screws.
- (3) Remove (pull upward) the printed board on which the transformer is installed.
- (4) Remove the clamping-nuts of the transformer band (covered with a vinyl tube). Remove the band.
- (5) Unsolder the lead wires of the transformer, and remove the transformer.

To re-install the high voltage transformer, follow the above procedure in the reverse sequence. After the high voltage oscillation transformer has been replaced, the high voltage must be re-calibrated. (For the recalibration, refer to Check and Calibration of High Voltage Power Supply of SECTION 6.)

MEMO

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SECTION OPERATION CHECK AND CALIBRATION



In order to maintain reliably the specified performance and accuracies, the SS-4100/SS-4100G must be checked and calibrated at regular intervals. This section explains the check and calibration procedure required for this purpose.

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INTERVALS OF OPERATION CHECK AND CALIBRATION

In order to check against variations in performances and accuracies caused by aging, the SS-4100/SS-4100G must be checked and calibrated at regular intervals. A recommendable time interval for this service, to ensure that the synchroscope is always operating in the reliable state, is 6 months.

INSTRUMENTS REQUIRED FOR OPERATION CHECK AND CALIBRATION

Various instruments are required for checking and calibrating the SS-4100/SS-4100G. Attention must be paid to the following points in using such instruments.

- (1) BNC connectors are used as input terminals of the SS-4100/SS-4100G. When the output terminal of a measuring instrument is not of the BNC type, an adaptor which can connect the output terminal to a BNC connector must be prepared. A binding-post terminal is used for the TRIG INPUT terminal of the SS-4100 or the EXT TRIG INPUT terminal of the SS-4100G. A BNC terminal adaptor which can connect the binding post terminal to a BNC connector is available from IWATSU. Refer to Section "OPTIONAL ACCESSORIES" at the end of this instruction manual.
- (2) The instruments used for this service must be of the same or better performances than those mentioned below, and must be properly calibrated.
- (3) The output of the signal generator used for this

service must be terminated with the proper output impedance.

- (4) The output voltage of a sine wave generator generally is shown in r.m.s. value. The relationship between the r.m.s. value and the peak-to-peak value which is measured and displayed by the SS-4100/SS-4100G is as given below:

$$\text{r.m.s. voltage} = \frac{\text{peak-to-peak voltage}}{2\sqrt{2}}$$

1. **Digital DC Voltmeter**
 Accuracy 0.2%
 Voltage measurement range 0 – 300 V
 < Example > IWATSU VOAC77
2. **High Voltage DC Voltmeter**
 Accuracy 5%
 Input resistance 1,000 MΩ
 Voltage measurement range 0 – 10 kV
 < Example > Combination of IWATSU VOAC77 and its High Voltage Probe
3. **Test Synchroscope (Oscilloscope)**
 Vertical deflection sensitivity 10 mV/cm or over
 Frequency bandwidth DC – 20 MHz or higher
 < Example > IWATSU SS-5157
4. **Sine Wave Generator**
 Frequency range 10 Hz – 50 kHz
 Output level 1 mV – 7.75 V (r.m.s.)

- Accuracy of output level 2% (must be calibrated better than 0.5% at 1 kHz)
5. **Standard Signal Generator**
 Frequency range 50 kHz — 50 MHz
 Output level 1 mV — 1 V (r.m.s.)
 Output level accuracy ± 1 dB
 (The required output level accuracy must be maintained when the frequency is varied.)
6. **Pulse Generator (I)**
 Frequency 1 kHz
 Rise time 0.1 μ sec or less
 Output level 0.2 mV — 100 V
 Output level accuracy Better than 1%
 < Example > CAL OUT of Test
 Synchroscope SS-5157
7. **Pulse Generator (II)**
 Frequencies 60 Hz, 1 kHz, 15 kHz,
 100 kHz, 250 kHz, and
 1 MHz
 Rise time 20 msec
 Output level 0 — 1 V
8. **Pulse Generator (III)**
 Frequency 400 kHz — 1 MHz
 Rise time 3 nsec
 Output level 0 — 1 V
9. **Time Marker Generator**
 Marker output 0.1 μ sec — 5 sec
 Time accuracy Better than 0.1%
 < Example > IWATSU PTG-1

10. **Ohmmeter**
 Resistance measurement range 0 — 2 M Ω
 Accuracy 1%
 < Example > IWATSU VOAC77
11. **Capacitance Meter**
 Capacitance measurement range 0 — 100 pF
 Accuracy 3%
12. **Accessories for Measurement**
 Probe 1016B1 B2) or 1017B1 (B2)
 (Accessory of SS-4100/SS-4100G)
 Dual input connector (T-type)
 50 Ω coaxial cables (approx. 50 cm long) 2
 < Example > IWATSU BB-500

PREPARATION FOR OPERATION CHECK AND CALIBRATION

To ensure the required accuracy, operation check and calibration of the SS-4100/SS-4100G must be performed in ambient temperature of 25°C $\pm$ 5°C. Also, allow about an hour of stabilization period. Before starting the operation check and calibration procedure, make preparations as below.

- (1) Connect a voltage regulator (auto-transformer) to the AC power line, confirm the line voltage, and adjust the voltage regulator output to the nominal voltage.
- (2) Connect the SS-4100/SS-4100G to the voltage regulator, and set the line voltage selector switch

(located on the rear panel of the synchroscope) in the position corresponding to the output of the voltage regulator.

- (3) Prior to turning on the power of the synchroscope, set the controls and switches of the front and right side panels as follows:

— CRT Circuit —

INTENSITY Fully counterclockwise position. However, after "CHECK AND CALIBRATION OF INTENSITY" is over, the intensity knob should be set in a position for adequate intensity.

FOCUS Mid-position. However, after "CHECK AND CALIBRATION OF FOCUS" is over, the focus knob should be set in a good focusing position.

SCALE ILLUM Adequate position.

— Vertical Deflection System —

The two identical controls (the same name) of CH 1 and CH 2 must be set in the same condition.

AC-GND-DC GND
VOLTS/DIV 10 mV
VARIABLE CALIB
 < SS-4100G only >
POSITION Mid-position

CH 2 POLARITY Unpressed state
(PUSH INV)
MODE CH 1

— Horizontal Deflection System —

HORIZ DISPLAY A
B MODE (PUSH TRIG) Unpressed state
A TIME/DIV 1 msec
A VARIABLE CALIB
 < SS-4100G only >
B TIME/DIV 1 msec
SWEEP STOP Unpressed state (off)
A SWEEP LENGTH Fully clockwise
DELAY TIME Fully counterclockwise
POSITION Mid-position
(PULL X 10 MAG) Mid-position, pushed
FINE state

— Trigger Circuit —

SOURCE INT CH 1
SWEEP MODE AUTO
COUPLING AC
PUSH+ SLOP LEVEL Mid-position, pushed
PULL- state
EXT TRIG SELECTOR NORM
 < SS-4100 only >
TRIG SELECTOR EXT
 < SS-4100G only >

- (4) After the above setting, turn on the POWER switch, turn clockwise the INTENSITY control so that the traces are displayed on the CRT screen, adjust the traces to adequate intensity, and allow about an hour of stabilization period.

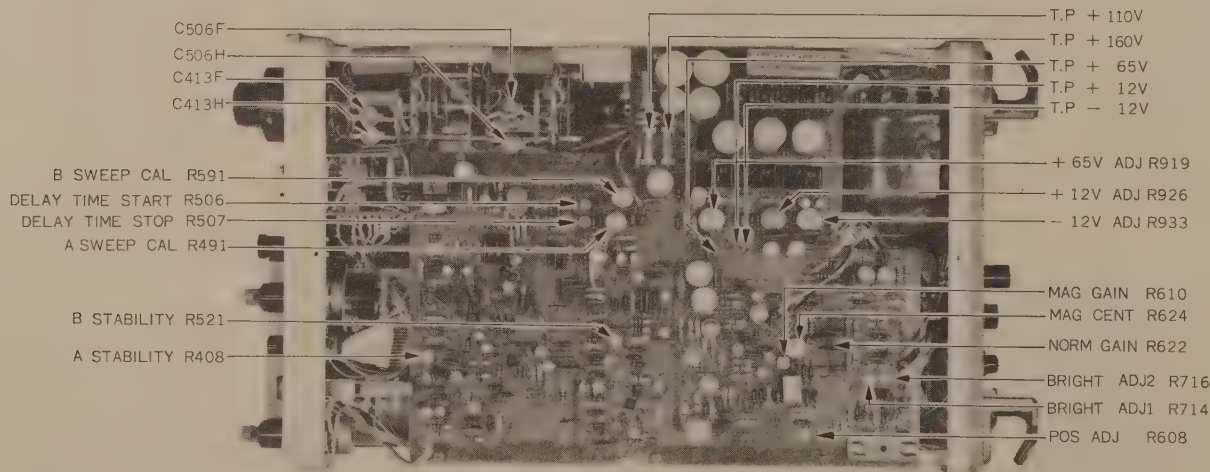
OPERATION CHECK AND CALIBRATION PROCEDURE

The procedure of operation check and calibration of individual function or circuit is described in this sub-section. Adjustment of controls and switches in the below paragraphs starts from the conditions described in the preceding sub-section "PREPARATION FOR OPERATION CHECK AND CALIBRATION." Even for calibra-

tion of limited items, the calibration procedure must always be started from the conditions described in the preceding sub-section "PREPARATION FOR OPERATION CHECK AND CALIBRATION."

When mal-functioning or a degraded accuracy which does not meet the specified performance is found, check and repair the cause of the mal-functioning or degraded accuracy by referring to Section 5 "TROUBLESHOOTING."

Figure 6-1 Bottom View of the Chassis



Low Voltage Power Supply and High Voltage Power Supply

Check and Calibration of Low Voltage Power Supply

The low voltage power supply must be accurately checked prior to calibration of other circuits since it provides operating voltages to these circuits. Calibration of these circuits are meaningless unless the power supply has been correctly calibrated beforehand.

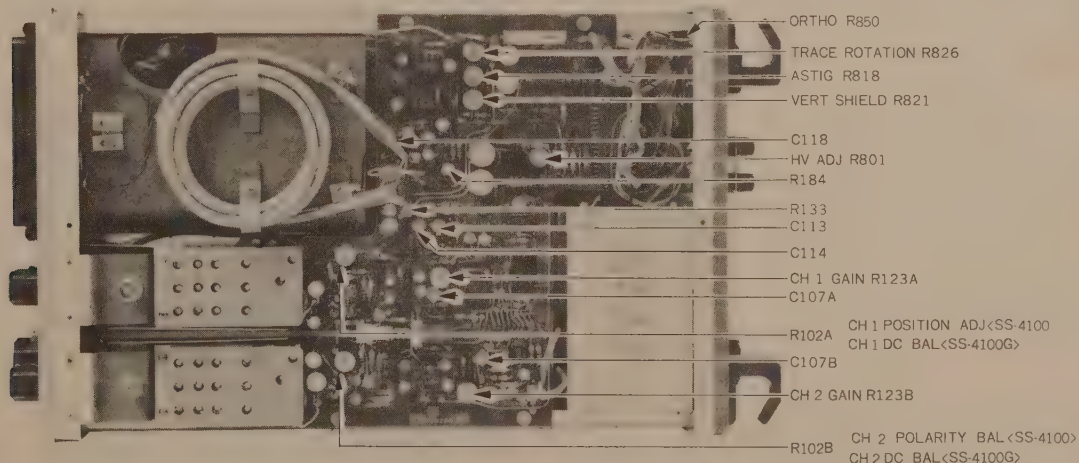
Normal Indication

Output voltages and ripple voltages are within the tolerances shown in Table 6-1.

Check and Calibration

- (1) Measure the DC voltages at the test points shown in Fig. 6-1 and check that they are within the tolerances shown in Table 6-1.
- (2) If the measured voltage is not within the specified

Figure 6-2 Top View of the Chassis



tolerance, adjust the corresponding calibration control (semi-fixed resistor) referring to Table 6-1 and Fig. 6-1.

- (3) Measure the ripple voltage of each supply voltage using the test synchroscope.

Table 6-1 Low supply voltages

Nominal supply voltage	Tolerance of supply voltage	Ripple voltage	Sequence of calibration	Calibration control
-12V	less than 2%	less than 0.5mV	1	R933
+12V	less than 2%	less than 0.5mV	2	R926
+65V	less than 2%	less than 1mV	3	R919
+110V	—	—	—	—
+160V	—	—	—	—

Check and Calibration of High Voltage Power Supply

High voltage power supply fluctuations will cause variations in the deflection sensitivity of both vertical and horizontal CRT axes. An excessive voltage variation will vary the focus and intensity of the beam. To prevent the above, the high voltage power supply must be properly adjusted.

Normal Indication

The voltage between cathode #2 of CRT and GND is $-1450\text{ V} \pm 50\text{ V}$.

Check and Calibration

- (1) Measure the voltage between cathode #2 of CRT and GND using the high voltage DC voltmeter, and check that the voltage is $-1450\text{ V} \pm 50\text{ V}$.

- (2) If the voltage is not within the above tolerance, adjust the voltage into the tolerance by means of HV. ADJ. R801 (see Fig. 6-2).
- (3) Measure the voltage between the anode of CRT and GND using the high voltage DC voltmeter, and check that the voltage is approximately $+5\text{ kV}$.

Check and Calibration of Intensity

Normal Indication

The trace disappears when the INTENSITY control is turned to the fully counterclockwise position. A bright spot appears when the INTENSITY control is turned to the fully clockwise position under the SWEEP STOP state.

Check and Calibration

- (1) Press the SWEEP STOP switch to stop the sweep. Adjust the spot to adequate brightness with the INTENSITY control.
- (2) Turn the BRIGHT ADJ 1, R714 (see Fig. 6-1) to the point where the spot is made brightest.
- (3) Set the SWEEP STOP switch to the "off" state so that the sweep is displayed. Adjust the trace to adequate brightness by means of the INTENSITY control.
- (4) Turn the BRIGHT ADJ 2, R716 (see Fig. 6-1) to the point where the trace is made brightest.
- (5) Turn the B TIME/DIV switch to the 0.1 mSEC position. Press the A INT BY B button of the HORIZ DISPLAY switch.
- (6) If the difference between the brightness of the A trace and that of the superimposed section of the A and B traces is excessively large, adjust slightly the

BRIGHT ADJ 1 & 2 (R714 and R716) mentioned in items (2) and (4) above.

Check and Calibration of Parallelism of Vertical and Horizontal Traces with Respect to the Graticule

Normal Indication

The vertical and horizontal traces are parallel with graticule scale lines.

Check and Calibration

- (1) Move the horizontal trace to the vertical center of the graticule by turning the VERT POSITION control. Adjust the trace to sharp focus with the FOCUS control.
- (2) Check for that the horizontal trace is parallel with the horizontal scale lines. If non-parallelism is found, adjust the TRACE ROTATION (located on the top panel) so that the correct parallelism is obtained.
- (3) Apply the output of the sine wave generator (at any frequency) to the CH 1 INPUT terminal, and set the AC-GND-DC switch in the DC state.
- (4) Adjust the output of the sine wave generator so that the trace is deflected with a vertical amplitude of 8 div. Press the SWEEP STOP button. Move the vertical trace to the vertical center of the graticule by turning the HORIZ POSITION control.
- (5) Check for that the vertical trace is parallel with the vertical scale lines. If non-parallelism is found, adjust the ORTHO, R850 (see Fig. 6-2) so that the correct parallelism is obtained.

Check and Calibration of Pattern Distortion

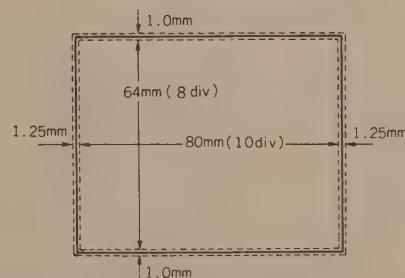
Normal Indication

When luster lines are displayed within the graticule scale ranges, deviation (bending) of luster lines from vertical scale lines is within 1.25 mm for a range of 64 mm (8 div) and that from horizontal scale lines is within 1.0 mm for a range of 80 mm (10 div) as shown in Fig. 6-3.

Check and Calibration

- (1) Apply the output of the sine wave generator at approximately 20 kHz to the CH 1 INPUT terminal. Set the AC-GND-DC switch in the DC state.
- (2) Adjust the output of the sine wave generator so that the signal is displayed as luster lines with an amplitude of 8 div (the top and bottom of the

Figure 6-3 Pattern Distortion



luster lines are aligned with the top and vertical scale lines of the graticule).

- (3) Align the start section of the luster lines with the left-hand end of the graticule by turning the HORIZ POSITION control.
- (4) In a similar manner as above, align the end section of the luster lines with the right-hand end of the graticule by turning the HORIZ POSITION control.
- (5) After adjustment of items (1) through (4) is complete, check for deviation (bending) of luster lines with respect to the peripheral lines (8 div X 10 div) of the graticule. Deviation of luster lines from the vertical scale lines must be within 1.25 mm for the range of 8 div and that from the horizontal scale lines must be within 1.0 mm for the range of 10 div.
- (6) If deviation is not within the above tolerances, turn the VERT SHIELD ADJ. R821 (see Fig. 6-2) to the point where the distortion is made minimum.

Check and Calibration of FOCUS

Normal Indication

Clearly focused trace is obtainable by turning the FOCUS control within 120 degrees of angle either clockwise or counterclockwise from its center.

Check and Calibration

- (1) Apply the output of the sine wave generator at 1 kHz to the CH 1 INPUT terminal. Set the AC-GND-DC switch in the DC state.
- (2) Adjust the output of the sine wave generator so that the signal is displayed with an amplitude of 8 div.

- (3) Obtain proper triggering by adjusting the LEVEL control.
- (4) Check that a clearly focused trace can be obtained by turning of the FOCUS control within a range of ± 120 degrees from the center.
- (5) If the trace is dim, adjust the ASTG R818 (located on the top panel) so that a clear trace is obtained.

Regulation Check of Low Voltage Power Supply

Normal Indication

The waveform displayed on the screen remains stable against line voltage variation for the range mentioned in the voltage range table of "POWER SUPPLY" of Section 1 "PERFORMANCE CHARACTERISTICS."

Check

- (1) Apply the output of the pulse generator (1) with 50 mV to the CH 1 INPUT terminal. Set the AC-GND-DC switch in the DC state.
- (2) Turn the LEVEL control to obtain proper triggering, and display a square waveform of 50 mm of amplitude on the screen.
- (3) Vary, continuously for a range of 90 – 110 V, the AC power input voltage of the synchroscope by means of the voltage regulator (auto-transformer).
- (4) Check that no intensity modulation or ripples are caused for the displayed waveform when the voltage is varied as above.
- (5) Turn the line voltage selector to the 115 V position, and vary the voltage for a range of 106 – 128 V continuously, and check the displayed waveform in the same manner as above.

- (6) After the above check is over, return the voltage regulator output to 100 V and the line voltage selector to the 100 V position.

Check of External Intensity Modulation

Normal Indication

Intensity modulation can be properly made with an input voltage of 2 Vp-p or over for a frequency range of 10 Hz — 10 MHz.

Check

- (1) Set the controls as below.

CH 1 AC-GND-DC	DC
CH 1 VOLTS/DIV	1 V
A TIME/DIV	20 mSEC
SWEEP MODE	NORM
- (2) Set the sine wave generator output at 2 Vp-p, 10 Hz. Branch off the output with the dual input connector, and apply the output simultaneously to the CH 1 INPUT terminal and the Z AXIS INPUT terminal (located on the rear panel).
- (3) Turn the LEVEL control to obtain proper triggering. If proper triggering is hardly attainable, however, the display may be left asynchronized.
- (4) Adjust the waveform to an adequate brightness with the INTENSITY control. Under this state, check that the lower section of the waveform is darkened as a result of intensity modulation.
- (5) Disconnect the sine wave generator. Apply the standard signal generator output (10 MHz, 2 Vp-p) simultaneously to the CH 1 INPUT terminal and Z AXIS INPUT terminal using the dual input connector.

- (6) Turn the A TIME/DIV switch to the 1 μ SEC position. Set the (PULL x 10 MAG) FINE control in the pulled state.
- (7) Turn the LEVEL control to obtain proper triggering.
- (8) Check that each cycle of the waveform has a darkened section as a result of intensity modulation.

Vertical Deflection System

Operation Check and Calibration of CH 1 Position <SS-4100 only>

Normal Indication

The trace is within the vertical range of the graticule when the CH 1 VERT POSITION control is set in the center position.

Check and Calibration

- (1) Turn the CH 1 VERT POSITION control to the center position.
- (2) Check that the trace is within the vertical range of the graticule.
- (3) If the trace is not within the graticule range, return the trace to the vertical center of the graticule by turning the CH 1 POSITION ADJ, R102A which is located on the top panel.

Balance Check and Calibration of CH 2 POLARITY and Operation Check of CH 2 POSITION <SS-4100 only>

Normal Indication

Vertical shift of the trace as a result of pressing of the

CH 2 POLARITY (PUSH INV) switch is within 3 div. When the CH 2 VERT POSITION control is set in the center position, the trace is within the vertical range of the graticule.

Check Calibration

- (1) Press the CH 2 button of the MODE selector, and move the trace to the vertical center of the graticule by turning the CH 2 VERT POSITION control.
- (2) Check for that the vertical shift of the trace as a result of pressing of the CH 2 POLARITY (PUSH INV) is less than 3 div.
- (3) If the shift is not within the above range, adjust the POLARITY BAL R102B (located on the top panel) so that the trace is not vertically shifted when the CH 2 POLARITY (PUSH INV) switch is pressed.
- (4) Check that the trace is in the vertical range of the graticule when the CH 2 VERT POSITION control is set in the center position.

Check and Calibration of DC BALANCE <SS-4100G only>

Normal Indication

The trace is not vertically shifted when the VARIABLE control is turned. The vertical shift of the trace as a result of pressing the CH 2 POLARITY (PUSH INV) button is less than 3 div.

Check and Calibration

- (1) Move the trace to the vertical center of the graticule by turning the CH 1 VERT POSITION control.

- (2) Check that the trace is not vertically shifted when the VARIABLE control is turned.
- (3) If the trace vertically shifts when the VARIABLE control is turned, adjust the CH 1 DC BAL, R102A (located on the top panel) so that the trace remains stationary.
- (4) Press the CH 2 button of the MODE selector, and perform the same procedure as items (1) through (3) above for CH 2 also. For CH 2, adjustment should be made with CH 2 DC BAL, R102B which also is located on the top panel.
- (5) Check that the vertical shift of the trace as a result of pressing the CH 2 POLARITY (PUSH INV) button is less than 3 div.

Operation Check of Vertical Position Control <SS-4100G only>

Normal Indication

The trace is within the vertical range of the scale when the POSITION control is set in the center position.

Check

- (1) Set the CH 1 POSITION control in the center position.
- (2) Check that the trace is within the vertical range of the graticule.
- (3) Press the CH 2 button of the MODE selector.
- (4) Turn the CH 2 VERT POSITION control to the center position, and check for that the trace is within the vertical scale range of the graticule.

Check and Calibration of Vertical Deflection Sensitivity

Normal Indication

The vertical deflection accuracy is better than $\pm 1\%$ for the 10 mV position and better than $\pm 2\%$ for the other positions (20 mV $\sim$ 10 V) of the VOLTS/DIV switch.

Check and Calibration

- (1) Apply the sine wave generator output at 1 kHz, 40 mVp-p to the CH 1 INPUT terminal. Set the AC-GND-DC switch in the DC state.
- (2) Move the waveform to the center of the graticule, and check that the deflection amplitude is within 4 div ± 0.04 div.
- (3) If the amplitude is not within the above tolerance, adjust accurately the amplitude with the CH 1 GAIN ADJ, H123A located on the top panel.
- (4) For the 20 mV to 10 V positions of the VOLTS/DIV switch, check for that the accuracy of the deflection amplitude is better than $\pm 2\%$ of the nominal values indicated by the VOLTS/DIV switch, referring to Table 6-2.
- (5) For CH 2 also, check and calibrate the vertical deflection sensitivity in the same manner as items (1) through (4) above, but by applying the sine wave generator output to the CH 2 INPUT terminal, pressing the CH 2 button of the MODE selector, and adjusting, if required, the CH 2 GAIN ADJ, R123B located on the top panel.

Note

If R123A or R123B has been adjusted in the procedure of vertical sensitivity calibration, repeat the procedure of "Operation Check and Calibration of CH 1 posi-

tion", "Balance Check and Calibration of CH 2 POLARITY and Operation Check of CH 2 POSITION" for the SS-4100 or the procedure of "Check and Calibration of DC BALANCE" for the SS-4100G.

Table 6-2

VOLTS/DIV	Sine Wave Generator Output	Vertical Amplitude (1 division=8mm)	Amplitude Corresponding to 2% Error
10mV	40mVp-p	4 division	Adjust for Zero Error } 0.08 division } 0.04 division
20mV	80mVp-p	4 division	
50mV	200mVp-p	4 division	
.1V	0.4Vp-p	4 division	
.2V	0.8Vp-p	4 division	
.5V	2Vp-p	4 division	
1V	4Vp-p	4 division	
2V	8Vp-p	4 division	
5V	20Vp-p	4 division	
10V	20Vp-p	2 division	

Operation Check of AC-GND-DC

Normal Indication

The input signal is properly connected in accordance with the setting of the AC-GND-DC seesaw switch.

Check

- (1) Apply the pulse generator (II) output at 20 mV to the CH 1 INPUT terminal.
- (2) Set the AC-GND-DC switch in the DC state, and obtain proper triggering with the LEVEL control. In

this case a square wave with an amplitude of 2 div should be displayed on the screen.

- (3) Align the bottom of the square wave with the vertical graticule center by turning the vertical POSITION control.
- (4) When the AC-GND-DC switch is changed to the GND state, the vertical amplitude should collapse to zero and horizontal line should be displayed at approximately vertical center of the graticule.
- (5) Change the AC-GND-DC switch to the AC state. When this is done, a square wave with an amplitude of 2 div (symmetrically with 1 div each to above and below the vertical center line of the graticule) should be displayed.
- (6) For the CH 2 also, check the function of the AC-GND-DC switch in the same manner as items (1) through (5) above, but applying the pulse wave generator output to the CH 2 INPUT terminal and pressing the CH 2 button of the MODE selector.

Check of ALT (Alternate) Operation

Normal Indication

The alternate operation is successfully made at any sweep time range.

Check

- (1) Press the ALT button of the MODE selector.
- (2) Adjust the POSITION controls of both channels so that the two traces are mutually apart by approximately 2 div.
- (3) Check that the traces of CH 1 and CH 2 are alternately swept, for all positions of the A TIME/DIV switch. Both traces should be simultaneously dis-

played when the A TIME/DIV switch is set in fast sweep speed positions.

Check of CHOP (Chopped) Operation

Normal Indication

Two traces are displayed under the chopped mode of operation.

Check

- (1) Press the CHOP button of the MODE switch.
- (2) Check that two traces are displayed on the screen. (If two traces are superimposed and are being displayed as a single line, separate the traces by turning the vertical POSITION control.)

Check of ADD (Added) Operation

Normal Indication

Check that the sum of the two input signals are displayed on the screen under the ADD mode of operation.

Check

- (1) Set the AC-GND-DC switches of both channels in the DC state.
- (2) Set the sine wave generator for 1 kHz, 20 mVp-p output. Apply the output simultaneously to both CH 1 and CH 2 INPUT terminals by using the dual input connector.
- (3) Press the ADD button of the MODE selector.
- (4) Check that the vertical amplitude of the waveform displayed in graticule center is 4 div ($\pm 2\%$).

Operation Check of CH 2 POLARITY (PUSH INV)**Normal Indication**

The polarity of the displayed waveform is inverted in response to pressing of the CH 2 POLARITY (PUSH INV) button.

Check

- (1) Set the AC-GND-DC switches of both channels in the DC state.
- (2) Set the sine wave generator for 1 kHz, 20 mVp-p output. Apply the output simultaneously to both CH 1 and CH 2 INPUT terminals using the dual input connector.
- (3) Press the ADD button of the MODE selector, and check that the vertical amplitude of the displayed waveform is 4 div.
- (4) Check that the waveform collapses to zero almost amplitude in response to pressing of the CH 2 POLARITY (PUSH INV) button.

Check of Common Mode Rejection Ratio under ADD Mode**Normal Indication**

The common mode rejection ratio at 1 kHz is higher than 40:1.

Check

- (1) Set the AC-BND-DC switches of both channels in the DC state.
- (2) Set the sine wave generator for 1 kHz, 10 mVp-p output. Apply the output to both CH 1 and CH 2 INPUT terminals simultaneously, using the dual

input connector.

- (3) Press the ADD button of the MODE selector.
- (4) Obtain proper triggering by adjusting the LEVEL control, and check that the vertical amplitude of the displayed waveform is approximately 2 div.
- (5) Increase the sine wave generator output to 100 mVp-p. Check that the vertical amplitude of the waveform is reduced to less than 0.25 div in response to pressing of the CH 2 POLARITY (PUSH INV) button.

Check and Calibration of INPUT RC (Resistance and Capacitance)**Normal Indication**

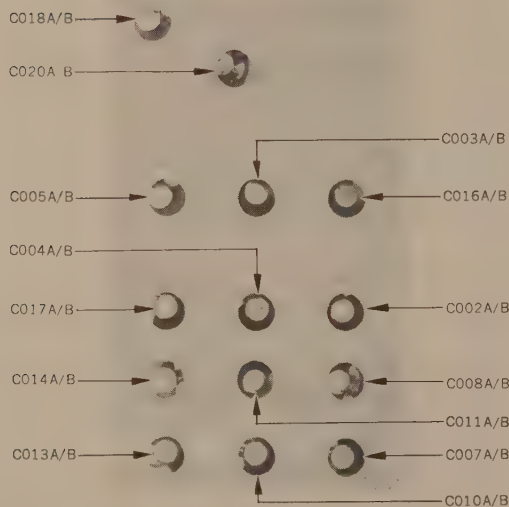
Of both CH 1 and CH 2, the input resistance is within $1\text{ M}\Omega \pm 2\%$ and the input capacitance is within $30\text{ pF} \pm 3\text{ pF}$.

Check and Calibration

- (1) Connect the capacitance meter to the CH 1 INPUT terminal, and set the AC-GND-DC switch in the DC state.
- (2) Check that the input capacitance as measured under the above state is within $30\text{ pF} \pm 3\text{ pF}$.
- (3) If the input capacitance is not within the specified tolerance, adjust CO18A (see Fig. 6-4) so that the input capacitance is made 30 pF .
- (4) Disconnect the capacitance meter and, in its place, connect the ohmmeter to the CH 1 INPUT terminal. Check that the input resistance is within $1\text{ M}\Omega \pm 2\%$.
- (5) Check the input capacitance and resistance of the CH 2 also in the same manner as items (1) through (4) above, but by pressing the CH 2 button of the

MODE selector and, if required, adjusting the capacitor CO18B (see Fig. 6-4).

Figure 6-4 Attenuator



Notes

- (1) If CO18A or CO18B has been adjusted for calibration of the input capacitance, repeat the procedure of "Check and Calibration of Attenuator Phase" which is described in the next sub-section. After the procedure is repeated, check the input capacitance and resistance for all positions of the VOLTS/DIV switch.
- (2) The input resistance cannot be accurately measured unless the DC voltage which is applied from the ohmmeter to the INPUT terminal is within the range (within ± 10 V) at which the diode connected to the gate of A102A/B of the preamplifier is not driven into the "on" state.

Check and Calibration of Attenuator Phase

Normal Indication

For each of the ranges of the VOLTS/DIV switches shown in Table 6-3, the phase shift is within $\pm 3\%$ when the 10:1 probe is used or within $\pm 2\%$ when no probe is used.

Check and Calibration

- (1) Set the AC-BND-DC switches of both channels in the DC state.
- (2) Connect the connector of the 1016B1 (B2) or 1017B1 (B2) probe to the CH 1 INPUT terminal, and connect the probe tip to the output of the pulse generator (I) set at 0.5 V.
- (3) Obtain proper triggering by adjusting the LEVEL control. Adjust the phase calibration capacitor of the probe so that the pulse head is made flat. For the calibration procedure hereunder, keep the

- capacitor in this calibrated state.
- (4) Check that the phase shift (section A shown in Fig. 6-5) is within $\pm 2\%$. If the phase shift is not within this tolerance, adjust C020A (see Fig. 6-4) so that the phase shift is eliminated.
 - (5) Turning the VOLTS/DIV switch of CH 1 from the 20 mV to 10 V positions and increasing correspondingly the pulse wave generator (I) output, check that the phase shift of section A shown in Fig. 6-5 is within $\pm 2\%$ and that of section B is within $\pm 3\%$ at each of the above-mentioned position of the VOLTS/DIV switch.
 - (6) If the phase shift is not within the specified tolerance, calibrate the corresponding calibration capacitor (see Table 6-3) so that the phase shift is eliminated.

Table 6-3

VOLTS/DIV	Calibration capacitors	
	Section A	Section B
10mV	C020A/B	C018B
20mV	C003A/B	C002A/B
50mV	C005A/B	C004A/B
.1V	C008A/B	C007A/B
.2V	C016A/B	Automatically calibrated
.5V	C017A/B	Automatically calibrated
1V	C011A/B	C010A/B
2V	Automatically calibrated	Automatically calibrated
5V	Automatically calibrated	Automatically calibrated
10V	C014A/B	C013A/B

Notes: In the above table, expression C003A/B, for example, simultaneously denotes C003A for CH 1 and C003B for CH 2.

- (7) Keeping the pulse generator output unaltered at 0.5 V, change the connection of the probe connector from the CH 1 INPUT terminal to the CH 2 INPUT terminal.
- (8) Check that the phase shift is within the above-mentioned tolerances. If the phase shift is not within the tolerance, eliminate the phase shift by adjusting C020B (see Fig. 6-4) for section A shown in Fig. 6-5 or by adjusting C018B (see Fig. 6-4) for section B.
- (9) In a similar manner as above, check and calibrate the phase shift by turning the VOLTS/DIV switch sequentially from the 20 mV position to the 10 V position and increasing the pulse generator (I) output accordingly. Calibration capacitors are mentioned in Table 6-3.

Check of Adjustable Range of VARIABLE Control

Normal Indication

The variable deflection sensitivity is continuously variable up to 2.5 times or over by turning the VARIABLE control. The UNCALIB CH 1 OR CH 2 lamp lights when the VARIABLE control is set in other position than CALIB.

Check

- (1) Apply the sine wave generator output at 50 mVp-p to the CH 1 INPUT terminal. Set the AC-GND-DC switch in the DC state.
- (2) Check for that, as the VARIABLE control is gradually turned counterclockwise, the vertical amplitude of the displayed waveform gradually

diminishes from 5 div and, when the VARIABLE control is turned to the extremely counterclockwise position, the vertical amplitude diminishes to less than 2 div.

- (3) Check for that the UNCALIB CH 1 OR CH 2 lamp lights unless the VARIABLE control is in the CALIB position.
- (4) Check the CH 2 also in the same manner as described in items (1) through (3) above, but by applying the sine wave generator output to the CH 2 INPUT terminal and pressing the CH 2 button of the MODE selector.

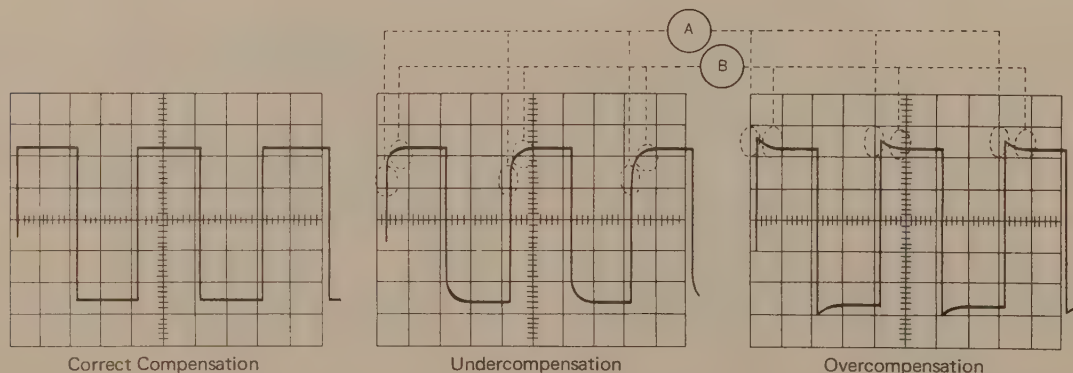
Check and Calibration of Square Wave Characteristics

Normal Indication

When a square wave having a rise time of 20 nsec is displayed with a vertical amplitude of 4 div in the center region of the graticule, distortions at each position of the VOLTS/DIV switch are within the below-mentioned tolerances.

Overshoot	Less than 3%
Rounding	Less than 2%
Ringing	Less than 1%
Matching distortion	Less than 2%
Sag	Less than 2%

Figure 6-5 Phase Calibration of Attenuator (VOLTS/DIV)



Check and Calibration

- (1) Set the AC-GND-DC switches of both channels in the DC state, the A TIME/DIV switch in the 1 μ SEC position, and the (PULL X 10 MAG) FINE knob in the pulled state.
- (2) Apply the pulse generator (II) output at 100 kHz to the CH 1 INPUT terminal.
- (3) Adjust the generator output so that the vertical amplitude of the displayed waveform is made 4 div. Obtain proper triggering by adjusting the LEVEL control. Move the leading edge of the displayed pulse waveform to the graticule center by turning the horizontal POSITION control.
- (4) Check that the distortions of the displayed pulse waveform is within the tolerances specified in **Normal Indication** above. If the distortions are not within the specified tolerances, proceed as below.
- (5) Adjust R184 (see Fig. 6-2) so that the matching distortion, which is produced at a section retarded by approximately 120 nsec from the leading edge of the pulse, is made minimum.
- (6) Adjust C107A, C113, C114, R133, R151, C117 and C118 (see Fig. 6-2) so that the leading edge (rise-up section) of the pulse waveform is made fastest of speed and least of distortions. For this waveform distortion calibration, use an output frequency of 100 kHz, 250 kHz, or 1 MHz of the pulse generator (II). Set the A TIME/DIV switch in a position convenient for waveform observation. For pulse waveform terminology, refer to Figs. 3-17 and 3-18.
- (7) Check the square wave characteristics for the CH 2 also, by applying the pulse wave generator (II) output to the CH 2 INPUT terminal and pressing the CH 2 button of the MODE selector.

- (8) If distortions are not within the specified tolerances, calibrate the characteristics by adjusting C107B (see Fig. 6-2) in the same manner as C107A was adjusted in foregoing item (5).
- (9) Set the A TIME/DIV switch in the 5 mSEC position and the (PULL X 10 MAG) FINE button in the pushed state.
- (10) Apply the pulse generator (II) output at 60 Hz to the INPUT connector, and check that the distortion is within the below-mentioned tolerance for both channels.

Sag	Less than 2%
-----	--------------

Check of Frequency Bandwidth**Normal Indication**

The frequency bandwidth is DC to 10 MHz for -3 dB drop.

Check

- (1) Apply the output of the standard signal generator at 50 kHz to the CH 1 INPUT terminal. Set the AC-GND-DC switch in the DC state.
- (2) Turn the LEVEL control clockwise or counterclockwise so that luster lines under free-run mode are displayed on the screen.
- (3) Adjust the vertical amplitude of the displayed waveform to 4 div by adjusting the standard signal generator output. The output under this state will be used as the reference level in the subsequent procedure.
- (4) Adjust the standard signal generator output at 10 MHz and at the reference level. Under this state,

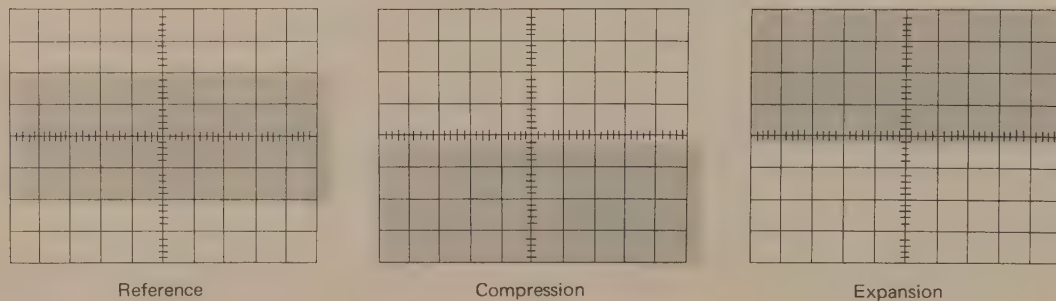
check that the vertical amplitude of the displayed waveform is not less than 2.85 div (amplitude drop is less than -3 dB). If the amplitude drop is greater than -3 dB, repeat the procedure of preceding subsection "CHECK AND CALIBRATION OF SQUARE WAVE CHARACTERISTICS."

(5) For all positions of the VOLTS/DIV switch, check

that the amplitude drop is not greater than -3 dB at 10 MHz.

(6) Check the CH 2 also in the same manner as items (1) through (5) above, but applying the standard signal generator output to the CH 2 INPUT terminal and pressing the CH 2 button of the MODE selector.

Figure 6-6 Vertical Linearity



Check of Linearity**Normal Indication**

The linearity is within $\pm 5\%$ at 10 MHz.

Check

- (1) Apply the standard signal generator output at 10 MHz to the CH 1 INPUT terminal. Set the AC-GND-DC switch in the DC state.
- (2) Adjust the vertical amplitude of the displayed waveform to 4 div by adjusting the standard signal generator output. Turn the LEVEL control clockwise or counterclockwise so that luster lines under free-run mode are displayed on the screen.
- (3) Check that, when the waveform is shifted to the upper limit and lower limit of the graticule, variations in the vertical amplitude of the displayed waveform is within 4 div $\pm 5\%$.
- (4) Check the linearity for the CH 2 also in the same manner as items (1) through (3) above, but by applying the standard signal generator output to the CH 2 INPUT terminal and pressing the CH 2 button of the MODE selector.

Trigger Circuit**Check of Trigger Signal Selection****Normal Indication**

Regarding the SS-4100, check for that triggering is made with the corresponding signal in response to pressing of the INT CH 1 INT CH 2, and EXT buttons of the SOURCE selector. Regarding the SS-4100G, check for that triggering is made with the corresponding signal in

response to pressing of the INT CH 1, INT CH 2, EXT, and LINE buttons of the SOURCE selector and setting of the TRIG SELECTOR.

Check-1 <for SS-4100>

- (1) Set the VOLTS/DIV switches of both channels in the 0.5 V position, and press the ALT button of the MODE selector.
- (2) Apply the pulse generator (I) output at 1 V to CH 1 INPUT AND CH 2 INPUT terminals simultaneously, using the dual input connector.
- (3) Check that triggering for the square wave with an amplitude of 2 div can be properly made by turning the LEVEL control, with the AC-GND-DC switch set in the DC state.
- (4) Change the AC-GND-DC switch of CH 1 to the GND state and that of CH 2 to the DC state.
- (5) Check that triggering for the square wave with an amplitude of 2 div can be properly made when the CH 2 button of the SOURCE selector is pressed.
- (6) Disconnect the pulse generator output from CH 1 INPUT terminal and connect it to the TRIG INPUT terminal (on the right side panel).
- (7) Check that triggering for the square wave with an amplitude of 2 div can be properly made by turning the LEVEL control, under the state the EXT button of the SOURCE switch is pressed.

Check-2 <for SS-4100G>

- (1) Perform the same procedure as described in items (1) through (5) of Check-1.
- (2) Disconnect the signal from the CH 1 INPUT terminal, and apply it to the EXT TRIG INPUT terminal (located on the right side panel).
- (3) Check that triggering for the square wave with an

amplitude of 2 div can be properly made by turning the LEVEL control, under the state the EXT button of the SOURCE selector is pressed.

- (4) Disconnect the pulse wave generator and dual input connector. Connect the connector of the 1016B1 (B2) or 1017B1 (B2) probe to the CH 1 INPUT terminal, and connect the probe tip to an AC line frequency signal source.
- (5) Check that stable triggering can be obtained by turning the LEVEL control, when the VOLTS/DIV switch is set in an appropriate range position and the TRIG SELECTOR switch (located on the right side panel) is thrown to the LINE position.

Check of INPUT RC of TRIG INPUT or EXT TRIG INPUT Circuit

Normal Indication

Of the TRIG INPUT < of SS-4100 > or the EXT TRIG INPUT < of SS-4100G >, the input resistance is $10\text{ M}\Omega \pm 10\%$ and the input capacitance is $42\text{ pF} \pm 5\text{ pF}$.

Check

- (1) Press the EXT button of the SOURCE selector. Press the DC EXT ONLY button of the COUPLING selector.
- (2) Connect the capacitance meter to the TRIG INPUT (or EXT TRIG INPUT) terminal, and check that the input capacitance is $42\text{ pF} \pm 5\text{ pF}$.
- (3) Disconnect the capacitance meter from the TRIG INPUT (or EXT TRIG INPUT) terminal, connect the ohmmeter in its place, and check that the input resistance is $1\text{ M}\Omega \pm 10\%$.

Notes

The input resistance cannot be accurately measured unless the DC voltage fed from the ohmmeter to the TRIG INPUT (or EXT TRIG INPUT) terminal is within the range ($\pm 10\text{ V}$) at which the diode, which is connected to the gate of Q310 of the input circuit, is not driven into the "on" state.

Operation Check of SLOPE Switch

Normal Indication

Triggering can be properly made with corresponding slope.

Check

- (1) Apply the sine wave generator output at 1 kHz to the CH 1 INPUT terminal. Adjust the vertical amplitude of the displayed waveform by adjusting the sine wave generator output. Set the AC-GND-DC switch in the DC state.
- (2) Obtain proper triggering by adjusting the LEVEL control.
- (3) Push and pull the slope switch, and check that the sweep is started by the positive slope of the trigger signal when the switch is pushed ("+" state) but it is started by the negative slope when the switch is pulled ("-" state).

Check and Calibration of LEVEL Control

Normal Indication

When the AUTO or NORM button of the SWEEP MODE selector is pressed, the LEVEL 0 (zero) point is in

a mid-position of the LEVEL control. The triggering level for the waveform is continuously variable for a range of 10% to 90% of the waveform slope.

Check and Calibration

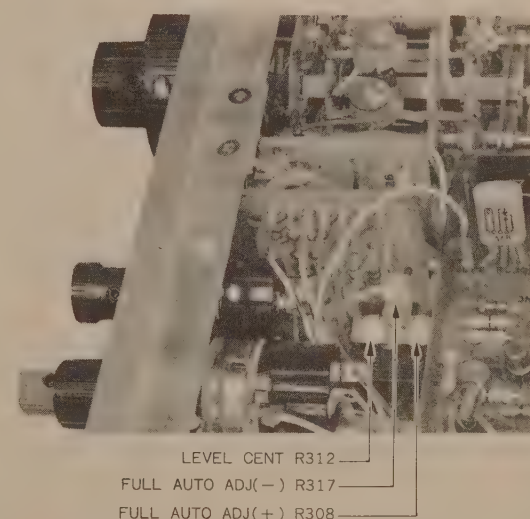
- (1) Apply the sine wave generator output at 1 kHz to the CH1 INPUT terminal. Adjust the vertical amplitude of the displayed waveform to 1 div by adjusting the sine wave generator output. Set the AC-GND-DC switch in the DC position.
- (2) Move the displayed waveform to the vertical center of the graticule by turning the vertical POSITION control.
- (3) Adjust the LEVEL control so that, when the SLOPE switch is pushed and pulled (switched between "+" and "-" states), the sweep from the positive slope and that from the negative slope are symmetrically displayed on the screen. Check that this position of the LEVEL control is in a mid-position of its total turning angle.
- (4) If the above position of the LEVEL control is apart from the mid-position, adjust the LEVEL CENT, R312 (see Fig. 6-7) so that the requirement of the above item (4) is satisfied.
- (5) Adjust the vertical amplitude of the displayed waveform to 8 div by adjusting the sine wave generator output.
- (6) Check that the sweep starting point moves on the slope of the sine wave continuously from the 10% position to the 90% position as the LEVEL control is turned. Perform this check for both "+" and "-" slopes by changing the SLOPE switch correspondingly.

Check and Calibration of FULL AUTO Operation

Normal Indication

Under the FULL AUTO mode of operation, the displayed waveform is properly triggered irrespective of full angle tuning of the LEVEL control.

Figure 6-7 FULL AUTO Circuit



Check and Calibration

- (1) Set the AC-GND-DC switch of CH 1 in the DC state, and press the FULL AUTO button of the SWEEP MODE selector.
- (2) Apply the sine wave generator output at 1 kHz to the CH 1 INPUT terminal, and adjust the vertical amplitude of the displayed waveform to 1 div by adjusting the sine wave generator output.
- (3) Move the displayed waveform to the graticule center by turning the vertical POSITION control.
- (4) Check that the waveform is properly triggered when the SLOPE switch is pushed and pulled alternately, under the state that the LEVEL control is turned to the fully counterclockwise position. If proper triggering is unattainable, adjust the FULL AUTO ADJ ("−"), R317 (refer to Fig. 6–7) so that proper triggering is obtained.
- (5) Check that the waveform is properly triggered when the SLOPE switch is pushed and pulled alternately, under the state that the LEVEL control is turned to the fully clockwise position. If proper triggering is unattainable, adjust the FULL AUTO ADJ ("+"), R308 (see Fig. 6–7).

Check of Internal Trigger Operation**Normal Indication**

Triggering is properly made at frequency ranges and trigger levels shown in Table 6–4.

Check

- (1) Set the AC-GND-DC switches of both channels in the DC state.
- (2) Apply the standard signal generator output at 10 MHz to the CH 1 INPUT terminal, and adjust the vertical amplitude of the displayed waveform to 1 div by adjusting the standard signal generator output. Press the NORM button of the SWEEP MODE selector.
- (3) Set the A TIME/DIV switch in a position for convenient observation of the waveform. Turning the LEVEL control, check that the displayed waveform is stably triggered.
- (4) Adjust the standard signal generator output frequency at 5 MHz and its voltage at 0.5 div as displayed on the screen. Under this state, perform the same check as above item (3).
- (5) Disconnect the standard signal generator, and connect the sine wave generator in its place. Apply the sine wave generator output at 30 Hz to the CH 1 INPUT terminal. Adjust the output at 0.5 div as displayed and, under this state, perform the same check as above item (3).
- (6) Press the HF REJ button of the COUPLING selector, and perform the same check as above item (3).
- (7) Adjust the sine wave generator output frequency at 10 kHz and its voltage at 0.5 div as displayed and, under this state, perform the same check as above item (3).
- (8) Press the AUTO button of the SWEEP MODE selector. Press the AC button and HF REJ button of the COUPLING selector in turns, and check the trigger frequency and trigger level in each case following the same procedure as described in above item (3) and referring to Table 6–4.
- (9) Press the FULL AUTO button of the SWEEP

MODE selector. Press the AC button and HF REJ button of the COUPLING selector in turns, and check the trigger frequency and trigger level in each case following the same procedure as described in above item (3) and referring to Table 6-4.

- (10) Check the CH 2 also in the same manner as items (1) through (9) above, but applying the standard signal generator output and sine wave generator output to the CH 2 INPUT terminal and pressing the CH 2 buttons of the MODE and SOURCE selectors.

Table 6-4 Internal trigger of A sweep

SWEEP MODE	COUPLING	Trigger frequency	Minimum trigger level (vertical amplitude, in div)
NORM	AC	30Hz — 5MHz 5MHz — 10MHz	0.5 1
	HF REJ	30Hz — 10kHz	0.5
AUTO	AC	50Hz — 5kHz 5MHz — 10MHz	0.5 1
	HF REJ	50Hz — 10kHz	0.5
FULL AUTO	AC	100Hz — 5MHz 5MHz — 10MHz	1 2
	HF REJ	100Hz — 10kHz	1

Check of External Trigger Operation

Normal Indication

Trigger is properly made at the frequency ranges and trigger levels shown in Table 6-5.

Check

- Set the switches as below.

AC-GND-DC switch of CH 1	DC
VOLTS/DIV switch of CH 1	0.2 V
SOURCE	EXT
SWEEP MODE	NORM
- Set the standard signal generator output at 10 MHz, 0.5 Vp-p. Branch off the output using the dual input connector, and connect one output to the CH 1 INPUT terminal and the other output to the TRIG INPUT terminal (for the SS-4100) or to the EXT TRIG INPUT terminal (for the SS-4100G).
- Set the A TIME/DIV switch in a position for adequate waveform amplitude. Check that the waveform can be stably triggered by adjusting the LEVEL control.
- Change the standard signal generator output to 5 MHz, 0.3 Vp-p, and perform the same check as above item (3).
- Disconnect the standard signal generator and connect the sine wave generator in its place. Set the sine wave generator output at 30 Hz, 0.3 Vp-p, and perform the same check as above item (3).
- Press the HF REJ button and DC EXT ONLY button of the COUPLING selector in turns, and check the trigger frequency and trigger level in each case by following the same procedure as described in above item (3) and referring to Table 6-5.

- (7) Press the AUTO button of the SWEEP MODE selector. Pressing the AC button, HF REJ button and DC EXT ONLY button of the COUPLING selector in turns, check the trigger frequency and trigger level in each case by following the same procedure as described in above item (3) and referring to Table 6-5.

Table 6-5

SWEEP MODE	COUPLING	Trigger frequency	Minimum trigger level (external trigger voltage)
NORM	AC	30Hz - 5MHz 5MHz - 10MHz	0.3Vp-p 0.5Vp-p
	HF REJ	30Hz - 10kHz	0.3Vp-p
	DC EXT ONLY	DC - 5MHz 5MHz - 10MHz	0.3Vp-p 0.5Vp-p
AUTO	AC	50Hz - 5MHz 5MHz - 10MHz	0.3Vp-p 0.5Vp-p
	HF REJ	50Hz - 10kHz	0.3Vp-p
	DC EXT ONLY	50Hz - 5MHz 5MHz - 10MHz	0.3Vp-p 0.5Vp-p
FULL AUTO	AC	100Hz - 10MHz	1Vp-p
	HF REJ	100Hz - 10kHz	1Vp-p
	DC EXT ONLY	100Hz - 10MHz	1Vp-p

- (8) Press the FULL AUTO button of the SWEEP MODE selector. Press the AC button, HF REJ button and DC EXT ONLY button of the COUPLING selector in turns, and check the trigger frequency and trigger level in each case by following the same procedure as described in above item (3) and referring to Table 6-5.

Check of AND GATE Operation <SS-4100 only>

Normal Indication

The AND GATE circuit properly performs the "and" logic operation.

Check

- (1) Throw the EXT TRIG SELECTOR switch (located on the right side panel) to the LOGIC position.
- (2) Connect the digital DC voltmeter to the MONITOR terminal (located on the right side panel). Check that the output voltage of the MONITOR terminal is approximately 2.6 V.
- (3) Short to GND the leftmost one of the AND GATE input terminals (located on the right side panel). Check that the output voltage of the MONITOR terminal is 0.6 V.
- (4) Check that the output voltage of 2.6 V is restored when leftmost terminal is disconnected from GND.
- (5) In the same manner as above, short to GND the 2nd, 3rd and 4th ones from the leftmost terminal in turns and check that the MONITOR output voltage is 0.6 V when any one of the terminals is shorted to GND but the voltage is restored to 2.6 V when shorting is removed.

Horizontal Deflection System

Check and Calibration of A Sweep Stability

Normal Indication

The A sweep generator circuit operates being synchronized with the trigger generator.

Check and Calibration

- (1) Set the AC-GND-DC switch of CH 1 in the DC state.
- (2) Apply the sine wave generator output at 1 kHz to the CH 1 INPUT terminal, and adjust the vertical amplitude of the displayed waveform to 2 div by adjusting the sine wave generator output.
- (3) Check that proper triggering can be obtained by turning the LEVEL control.
- (4) If triggering is unsuccessful and sweeps occur in the free-run mode or no sweep at all is displayed, adjust the A STABILITY, R408 (see Fig. 6-1) so that proper triggering is obtained. In this case, set R408 in a mid-position of the turning angle range within which triggering can be successfully made.

Check and Calibration of B Sweep Stability

Normal Indication

The B sweep generator circuit operates being synchronized with the trigger generator.

Check and Calibration

- (1) Set the AC-GND-DC switch of CH 1 in the DC state.

- (2) Apply the sine wave generator output at 1 kHz to the CH 1 INPUT terminal. Adjust the vertical amplitude of the displayed waveform to 2 div by adjusting the sine wave generator output. Obtain proper triggering by turning the LEVEL control.
- (3) Set the switches as below.

B TIME/DIV	50 μ SEC
HORIZ DISPLAY	A INT BY B
B MODE (PUSH TRIG)	Pushed state
- (4) Check for that, as the DELAY TIME knob is turned clockwise, the brighter section of the B sweep (being superimposed by the A sweep— moves intermittently).
- (5) If the brighter section of the B sweep moves continuously or disappears, adjust the B STABILITY, R521 (see Fig. 6-1) so that the condition of above item (4) is obtained. In this case, set R521 in a mid-position of the turning angle range within which triggering can be successfully made.

Check and Calibration of A Sweep Time Accuracy

Normal Indication

The actual sweep time is within $\pm 2\%$ of the nominal value indicated by the A TIME/DIV switch (but within $\pm 5\%$ for the 0.5 μ SEC position only).

Check and Calibration

- (1) Set the AC-GND-DC switch of CH 1 in the DC state.
- (2) Apply the time marker generator output at 1 msec to CH 1 INPUT terminal. Obtain proper triggering by adjusting the LEVEL control.

- (3) Check for that, when the initial marker is aligned with the left hand end of the horizontal scale, the 11th marker is positioned within ± 0.2 div ($\pm 2\%$) of the right hand end of the horizontal scale. If the 11th marker is not within the above tolerance, calibrate the marker position following the procedure as described in items (4) and (5) below.
- (4) Adjust the trace length to the 12th marker by turning the A SWEEP CAL, R491 (see Fig. 6-1). In this case, the marker positions may not conform with the horizontal scale index.
- (5) Align the initial marker with the left hand end of the horizontal scale by turning the horizontal POSITION control. Adjust the NORM CAIN, R622 (see Fig. 6-1) so that the markers are aligned with respective horizontal division marks up to the right hand end of the horizontal scale.
- (6) Turning the A TIME/DIV switch sequentially to all its positions and varying the time generator output period so that one marker is displayed per one scale division, check for that, when the initial marker is aligned with the left hand end of the horizontal scale, the final marker is positioned within ± 0.2 div ($\pm 2\%$) from the right hand end of the horizontal scale. The relationship between the time marker generator output period and the number of displayed time markers, for respective positions of the A TIME/DIV switch, is as shown in Table 6-6.
- (7) If deviation of the marker is not within the above-specified tolerance when the A TIME/DIV switch is set in the $1\ \mu\text{SEC}$ or $0.5\ \mu\text{SEC}$ position, calibrate the marker position by adjusting C413F (see Fig. 6-1) for the $1\ \mu\text{SEC}$ position or C413H (see Fig. 6-1) for the $0.5\ \mu\text{SEC}$ position.

Table 6-6

A, B TIME/DIV	Time maker generator output period	The number of displayed time makers
.5 μSEC	0.5 μSEC	1/division
1 μSEC	1 μSEC	1/division
2 μSEC	2 μSEC	1/division
5 μSEC	5 μSEC	1/division
10 μSEC	10 μSEC	1/division
20 μSEC	20 μSEC	1/division
50 μSEC	50 μSEC	1/division
.1 mSEC	0.1 mSEC	1/division
.2 mSEC	0.2 mSEC	1/division
1 mSEC	1 mSEC	1/division
2 mSEC	2 mSEC	1/division
5 mSEC	5 mSEC	1/division
10 mSEC	10 mSEC	1/division
20 mSEC	20 mSEC	1/division
50 mSEC	50 mSEC	1/division
.1 SEC	0.1 SEC	1/division
.2 SEC	0.2 SEC	1/division
.5 SEC	0.5 SEC	1/division

Check and Calibration of A Sweep Magnification Accuracy

Normal Indication

The accuracy of A sweep magnification by a factor of 10 is better than $\pm 5\%$.

Check and Calibration

- (1) Set the AC-GND-DC switch of CH 1 in the DC state.

- (2) Apply the time marker generator output at 0.1 msec to the CH 1 INPUT terminal. Obtain proper triggering by adjusting the LEVEL control.
- (3) Set the (PULL X 10 MAG) FINE knob in the pulled state. Check for that, when the initial marker is aligned with the left hand end of the horizontal scale, subsequent markers are positioned at corresponding division marks of the scale and the final marker is positioned within ± 0.5 div ($\pm 5\%$) from the right hand end of the horizontal scale.
- (4) If the final marker is not positioned within the specified tolerance from the right hand end of the horizontal scale, adjust MAG GAIN, R610 (see Fig. 6-1) so that the marker is accurately aligned with the scale mark.
- (5) Turning the A TIME/DIV switch sequentially to all its positions and varying the time generator output period so that one marker is displayed per one scale division, check for that, when the initial marker is aligned with the left hand end of the horizontal scale, the final marker is positioned within ± 0.5 div ($\pm 5\%$) from the right hand end of the horizontal scale.

Notes

If the MAG GAIN, R610, has been adjusted in the procedure of the above item (4), the NORM GAIN, R622, mentioned in the preceding sub-section "Check and Calibration of A Sweep Time Accuracy" must be rechecked. Repeat adjustments of R610 and R622 in turns for a few times.

Check of A VARIABLE Range <SS-4100G only>

Normal Indication

The sweep time is continuously variable up to a factor of 2.5 or over by turning the A VARIABLE control. The UNCALIB neon lamp lights unless the A VARIABLE control is set in the CALIB position.

Check

- (1) Set the AC-GND-DC switch of CH 1 in the DC state. Set the A TIME/DIV switch in the 0.2 mSEC position.
- (2) Apply the time marker generator output at 0.5 msec to the CH 1 INPUT terminal. Obtain proper triggering by turning the LEVEL control.
- (3) Under the above state, check that the distance between two adjoining markers is 2.5 div.
- (4) Check that the UNCALIB neon lamp lights unless the A VARIABLE control is in the CALIB position.

Check and Calibration of B Sweep Time Accuracy

Normal Indication

The actual sweep time is within $\pm 2\%$ of the nominal value indicated by the B TIME/DIV switch (but within $\pm 5\%$ for the 0.5 μ SEC/DIV position only).

Check and Calibration

- (1) Set the AC-GND-DC switch of CH 1 in the DC state. Press the DLY'D(B) button of the HORIZ DISPLAY selector.
- (2) Apply the time marker generator output at 1 msec to the CH 1 INPUT terminal. Obtain proper triggering by turning the LEVEL control.

- (3) Check for that, when the initial marker is aligned with the left hand end of the horizontal scale, the 11th marker is positioned within ± 0.2 div ($\pm 2\%$) of the right hand end of the horizontal scale.
- (4) If the 11th marker is not within the above tolerance, align the initial marker with the left hand end of the horizontal scale and adjust the B SWEEP CAL, R591 (see Fig. 6-1) so that the other markers are aligned with corresponding division marks of the horizontal scale and the final marker is accurately aligned with the right hand end of the horizontal scale.
- (5) Turning the B TIME/DIV switch sequentially to all its positions and varying the time generator output period so that one marker is displayed per one scale division, check for that, when the initial marker is aligned with the left hand end of the horizontal scale, the final marker is positioned within ± 0.2 div ($\pm 2\%$) from the right hand end of the horizontal scale. The relationship between the time marker generator output period and the number of displayed time markers, for respective positions of the B TIME/DIV switch, is as shown in Table 6-6.
- (6) If deviation of the marker is not within the above-specified tolerance when the B TIME/DIV switch is set in the $1\ \mu\text{SEC}$ or $0.5\ \mu\text{SEC}$ position, calibrate the marker position by adjusting C506F (see Fig. 6-1) for the $1\ \mu\text{SEC}$ range or C506H (see Fig. 6-1) for the $0.5\ \mu\text{SEC}$ range.

Check of B Sweep Magnification Accuracy

Normal Indications,

The accuracy of B sweep magnification by a factor of

10 is better than $\pm 5\%$.

Check

- (1) Set the AC-GND-DC switch of CH 1 in the DC state. Press the DLY'D(B) button of the HORIZ DISPLAY selector.
- (2) Apply the time marker generator output at $0.1\ \text{msec}$ to the CH 1 INPUT terminal. Obtain proper triggering by turning the LEVEL control.
- (3) Set the (PULL X 10 MAG) FINE knob in the pulled state. Check for that, when the initial marker is aligned with the left hand end of the horizontal scale, subsequent markers are positioned at corresponding division marks of the scale and the final marker is positioned within ± 0.5 div ($\pm 5\%$) from the right hand end of the horizontal scale.
- (4) Turning the B TIME/DIV switch sequentially and varying the time marker generator output period accordingly, check that the requirement of the above item (3) is satisfied at all positions of the B TIME/DIV switch. In this case, the A TIME/DIV switch must be set in the same position with that of the B TIME/DIV switch.

Check and Calibration of Sweep Center Shift in MAG Operation

Normal Indication

Horizontal shift of the sweep start point is within 0.5 div.

Check and Calibration

- (1) Set the (PULL X 10 MAG) FINE knob in the pulled state. Move the start point of the trace to the

horizontal center of the graticule by turning the horizontal POSITION control.

- (2) Press the (PULL X 10 MAG) FINE knob, and check that the resultant shift of the start point of the trace is less than 0.5 div from the horizontal center of the graticule.
- (3) If the shift of the trace is larger than the above tolerance, adjust MAG CENT, R624 (see Fig. 6-1) so that the start point of the trace remains in the horizontal center of the graticule irrespective of pressing of the (PULL X 10 MAG) FINE knob.
- (4) Turn the HORIZ POSITION control and FINE control to their fully counterclockwise positions. Under this state, check for that the terminating point of the trace is in the left hand region from the horizontal center of the graticule.
- (5) If the trace end is in the right hand region from the horizontal center of the graticule, adjust the POS ADJ, R608 (see Fig. 6-1) so that the trace end is moved to a position leftward from the horizontal center by a few divisions.
- (6) Repeat for a few times the check and calibration procedure of the above items (1) through (5).

Check of Trace Length

Normal Indication

The trace length is continuously variable for a range of approximately 3.5 div to 11 div.

Check

- (1) Check that the trace length becomes approximately 11 div when the A SWEEP LENGTH (located on

the right side panel) is turned to the fully clockwise position.

- (2) Check that the trace length diminishes as the A SWEEP LENGTH control is turned counterclockwise and the length ultimately becomes approximately 3.5 div when the control is turned to the extremely counterclockwise position. If the trace length is abnormal, repeat the procedure of "CHECK AND CALIBRATION OF A SWEEP TIME ACCURACY."

Check and Calibration of Delay Time

Normal Indication

The delay time is adjustable for a range of 0.5 div (± 0.2 div) to 10.5 div (± 0.2 div) by turning the DELAY TIME control.

Check and Calibration

- (1) Set the B TIME/DIV switch in the 0.1 mSEC position. Press the A INT BY B button of the HORIZ DISPLAY selector.
- (2) Move the start point of the A trace to the left hand end of the horizontal scale by turning the horizontal POSITION control.
- (3) Check that the start point of B trace (this point is identified as a brighter point on the A trace being superimposed by the trace) is within 0.5 div ± 0.2 div from the left hand end of the horizontal scale.
- (4) If the start point is not within the above tolerance, adjust the DELAY TIME START, R506 (see Fig. 6-1) so that the start point is moved to the

position of 0.5 div from the left hand end of the horizontal scale.

- (5) Turn the DELAY TIME control to the extremely clockwise position.
- (6) Under the above state, check that the start point of B trace is within 10.5 div ± 0.2 div of the A trace.
- (7) If the start point of the B trace is not within the above tolerance, adjust the DELAY TIME STOP, R507 (see Fig. 6-1) so that the start point is moved to the 10.5 div position of the A sweep.
- (8) Repeat for a few times the procedure of the above items (3) through (7).

Check of Variable Range of Delay Time

Normal Indication

The delay time is variable for a range of 1 μ sec to 5 sec.

Check

- (1) Press the A INT BY B button of the HORIZ DISPLAY selector.
- (2) Align the start point of the A sweep with the left hand end of the horizontal scale by turning the HORIZ POSITION control.
- (3) Check for that, as the DELAY TIME control is turned for its full adjusting angle, the start point of the B sweep (the brighter point on the sweep) moves from a position of approximately 0.5 div from the left hand end of the horizontal scale to a position of approximately 10.5 div for all range positions of the A and B TIME/DIV switches as shown in Table 6-7.

Table 6-7

A TIME/DIV	B TIME/DIV
1 μ SEC	1 μ SEC
2 μ SEC	2 μ SEC
5 μ SEC	5 μ SEC
10 μ SEC	10 μ SEC
20 μ SEC	20 μ SEC
50 μ SEC	50 μ SEC
.1mSEC	.1mSEC
.2mSEC	.2mSEC
.5mSEC	.5mSEC
1mSEC	1mSEC
2mSEC	2mSEC
5mSEC	5mSEC
10mSEC	10mSEC
20mSEC	20mSEC
50mSEC	50mSEC
.1 SEC	.1 SEC
.2 SEC	.2 SEC
.5 SEC	.5 SEC

Check of Delay Jitter

Normal Indication

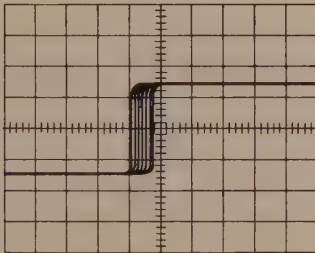
Delay jitter is less than 1/20000.

Check

- (1) Set the AC-GND-DC switch of CH 1 in the DC state. Set the B TIME/DIV switch in the 0.5 μ SEC position.
- (2) Press the A INT BY B button of the HORIZ DISPLAY selector.

- (3) Apply the pulse generator (1) output as 1 kHz to the CH 1 INPUT terminal, and adjust the amplitude of the displayed waveform to approximately 4 div by adjusting the generator output. Obtain proper triggering by turning the LEVEL control.
- (4) Adjust the DELAY TIME control so that the brighter section of the B sweep includes the leading edge of the 10th square wave.
- (5) Press the DLY'D(B) button of the HORIZ DISPLAY switch.
- (6) Slightly move the DELAY TIME control so that the leading edge (rise-up section) of the square wave is displayed in a mid-position of the graticule.
- (7) Under the above condition, check that the jitter amplitude is less than 1 div. (See Fig. 6-8).

Figure 6-8 Delay Jitter



Check of Single Sweep Operation <SS-4100G only>

Normal Indication

The sweep is produced only once when the RESET button is pressed. If no signal is applied after the RESET button is pressed, the circuit remains in the "ready" state.

Check

- (1) Set the AC-GND-DC switch of CH 1 in the DC state.
- (2) Apply the pulse generator output at 1 kHz, 10 mV to the CH 1 INPUT terminal. Obtain proper triggering by turning the LEVEL control.
- (3) Press the SINGLE button of the SWEEP MODE selector.
- (4) Check for that, at the instant the RESET button is pressed, the sweep runs only for once in the synchronized made. Also check for that this single sweep operation can be normally made either in the "+" or "-" state (pushed or pulled state) of the SLOPE knob.
- (5) Check for that, when the AG-GND-DC switch of CH 1 is changed to the GND state and the RESET button is pressed, no sweep is produced and the neon lamp of the RESET button turns on.
- (6) Check for that, when the AC-GND-DC switch is returned to the DC state, the sweep runs only for once and the lamp of the RESET button turns off.

Check of SWEEP STOP Operation

Normal Indication

When the SWEEP STOP button is pressed, the sweep

stops and the electron beam is displayed as a spot on the CRT screen.

Check

- (1) Ensure that, when the SWEEP STOP button is not pressed, a trace with a certain horizontal amplitude is displayed on the screen.
- (2) Check for that, at the instant the SWEEP STOP button is pressed, the trace converges into a stationary spot which is brighter the trace has been.

Check of Signal Delay Time

Normal Indication

A signal delay time of approximately 27 nsec or over as measured on the graticule can be obtained.

Check

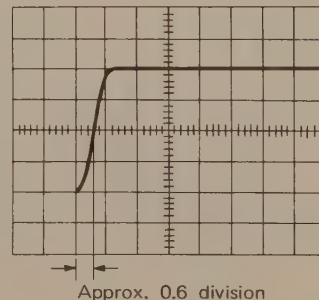
- (1) Set the switches as below.

AC-GND-DC of CH 1:	DC
A TIME/DIV:	0.5 μ SEC
(PULL X 10 MAG) FINE:	Pulled state
- (2) Apply the pulse wave generator (III) output at 1 MHz to the CH 1 INPUT terminal. Adjust the vertical amplitude of the displayed waveform to 4 div by adjusting the generator output.
- (3) Move the leading edge of the square wave to within the graticule range by turning the horizontal POSITION control.
- (4) Turn the LEVEL control in the direction the leading edge (rise-up section) of the square wave is fully displayed and set it in such a critical point that

triggering becomes unsuccessful if the control is turned any further.

- (5) Turn clockwise the INTENSITY control to make the displayed waveform sufficiently bright.
- (6) Under the above state, check for that the period from the sweep start to the instant the amplitude grows up to a half of the full amplitude of the square wave is approximately 0.6 div as measured on the graticule (see Fig. 6–9).

Figure 6–9 Observation of Signal Delay Time



Calibrator

Check of Voltage Accuracy of Calibrator

Normal Indication

The output voltage of the CAL 4 V terminal is within 4 V $\pm 2\%$.

Check

- (1) Set the AC-GND-DC switch of CH 1 in the DC state and the VOLTS/DIV switch in the 1 V position.
- (2) Apply the sine wave generator output at 1 kHz, 4 Vp-p to the CH 1 INPUT terminal. Under this condition, accurately read the vertical amplitude of the displayed waveform.
- (3) Disconnect the sine wave generator. Connect the CAL 4 V terminal to the CH 1 INPUT terminal.
- (4) Under the above state, check that the vertical amplitude is within $\pm 2\%$ of that of the above item (2).

Check of Accuracy of CAL 4 V Range Position

Normal Indication

When the VOLTS/DIV switch is set in the CAL 4 V range position, the voltage accuracy of the calibration signal is better than 4 div $\pm 2\%$ of vertical amplitude as measured on the graticule.

Check

- (1) Set the VOLTS/DIV switches of both channels in their CAL 4 V positions.

- (2) Check that the vertical amplitude of the displayed waveform is within 4 div $\pm 2\%$.
- (3) Press the CH 2 button of the MODE selector, and check the amplitude in the same manner as above item (2).

Check of Calibrator Frequency

Normal Indication

The frequency of the calibration signal is within 1 kHz $\pm 5\%$.

Check

- (1) Set the AC-GND-DC switch of CH 1 in the DC state.
- (2) Apply the time marker generator output at 1 msec to the CH 1 INPUT terminal.
- (3) Obtain proper triggering by adjusting the LEVEL control. Align the initial marker with the left hand end of the horizontal scale by turning the horizontal POSITION control. Read accurately the position of the 11th marker on the horizontal scale of the graticule.
- (4) Turn the VOLTS/DIV switch of CH 2 to the CAL 4 V position. Press the CH 2 button of the MODE selector.
- (5) Obtain proper triggering by adjusting the LEVEL control. Align the leading edge of the calibration signal with the left hand end of the horizontal scale.
- (6) Check for that the deviation of the position of the end of the 10th cycle of the calibration signal from the 11th marker position as measured in the above item (4) is within ± 0.05 div ($\pm 0.5\%$).

Check of Duty Ratio of Calibration Signal

Normal Indication

The duty ratio of the calibration square wave signal is within 48:52.

Check

- (1) Set the VOLTS/DIV switch of CH 1 in the CAL 4 DIV position.
- (2) Set the A TIME/DIV switch in the 0.1 mSEC position. Obtain proper triggering by adjusting the LEVEL control.
- (3) Measure the widths of two adjoining half-cycles of the displayed waveform, with the horizontal scale of the graticule. Check that ratio of the two widths is closer to unity than 48:52.

Check of Rise Time of Calibration Signal

Normal Indication

The rise time of the calibration signal is faster than $0.5 \mu\text{sec}$.

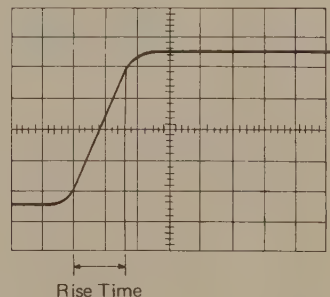
Check

- (1) Apply the output signal of the CAL 4 V terminal to the test synchroscope.
- (2) Adjust the test synchroscope so that the calibration signal is displayed with an amplitude of 50 mm

(divisions) symmetrically with respect to the vertical center of the graticule as shown in Fig. 6-10.

- (3) Check for that the horizontal distance between the two points of 10% and 90% of full vertical amplitude represents a period of less than $0.5 \mu\text{sec}$.

Figure 6-10 Rise Time of Calibration Signal



Waveform Displayed on Test Synchroscope

7

SECTION 7 PARTS LIST

This section particularly describes the specification of parts, for replacement of defective parts when the instrument is troubled.

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Ordering Information

Replacement parts may be ordered through an IWATSU Representative or directly from the factory. To be certain of receiving the proper parts, always include the following information with the order:

- a. Model Number and serial number of the instrument on which the parts will be installed.
- b. Circuit reference number and subassembly name, if applicable, for which the part is intended. If the part does not have a circuit reference, the description from the parts list should be used.
- c. Iwatsu part number.

For factory repair, contact the IWATSU agent and include the following information.

- a. Model number and serial number of the instrument on which the work is to be performed.
 - b. Details concerning the nature of the malfunction, or, type of repair desired.
- Shipping instructions will be sent to you promptly.

How To Use This Parts List

The parts list is divided into subsections corresponding to the schematic diagrams such as VERTICAL AMP, TRIG CIRCUIT, SWEEP GENERATOR, HORIZONTAL AMP, CRT CIRCUIT and POWER SUPPLY. Component loca-

tions can be determined from the schematic diagrams, each component appears only once in the parts list. At the beginning of each subsection are listed part numbers for any complete subassemblies in that category that are available as replacement parts. These subassemblies may include individually-listed components; care should be taken to locate malfunctions to the lowest possible level of replacement part and thus avoid the time and cost involved in "over-repair".

Abbreviations

Cap.	Capacitor
cer.	ceramic
poly.....	polyethytl film condenser
elect.	aluminium electrolytic chemical con- denser
elect. tan.	tan-talum electrolytic chemical condenser
[The symbol of F (farad) is omitted]	
Res.	Resistor
w.w.	wire wound
comp.	composition
[The symbol of Ω (ohm) is omitted]	
FET	Field Effect Transistor
Diode	
T.Diode	Tunnel Diode
Z.Diode	Zenner Diode
Var.	variable

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.
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— ATTENUATOR —

C001 A.B	Cap., 0.1 μ , $\pm 20\%$, 600V, poly	74 130 010 0
C002 A.B	Cap., 4.5–15p, var., 250V, cer.	74 110 085 0
C003 A.B	Cap., 6–20p, var., 250V, cer.	74 110 087 0
C004 A.B	Same as C002 A.B	
C005 A.B	Same as C002 A.B	
C006 A.B	Cap., 10p, $\pm 1p$, 500V, cer.	74 050 192 0
C007 A.B	Same as C003 A.B	
C008 A.B	Same as C002 A.B	
C009 A.B	Cap., 20p, $\pm 5\%$, 500V, cer.	74 050 537 0
C010 A.B	Same as C003 A.B	
C011 A.B	Same as C002 A.B	
C012 A.B	Cap., 470p, $\pm 2\%$, 300V, cer.	74 090 491 0
C013 A.B	Same as C003 A.B	
C014 A.B	Cap., 3–7p, var., 250V, cer.	74 110 081 0
C015 A.B	Cap., 2700p, $\pm 2\%$, 300V, cer.	74 090 490 0
C016 A.B	Cap., 3.5–10p, var., 250V, cer.	74 110 084 0
C017 A.B	Same as C002 A.B	
C018 A.B	Same as C014 A.B	
C019 A.B	Cap., 62p, $\pm 5\%$, 500V, cer.	74 050 618 0
C020 A.B	Cap., 8.5–30p, var., 250V, cer.	74 110 089 0
C021 A.B	Cap., 0.01 μ , +100%–0%, 500V, cer.	74 060 073 0
C023 A.B	Cap., 5p, $\pm 0.5p$, 500V, cer.	74 050 191 0

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.
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R001 A.B	Res., 47, $\pm 5\%$, 1/4W, compo.	74 253 007 0
R002 A.B	Res., 10, $\pm 5\%$, 1/4W, compo.	74 253 044 0
R003 A.B	Res., 500k, $\pm 0.5\%$, 1/2W, metal	74 221 277 0
R004 A.B	Res., 1M, $\pm 0.5\%$, 1/2W, metal	74 221 234 0
R005 A.B	Res., 800k, $\pm 0.5\%$, 1/2W, metal	74 221 242 0
R006 A.B	Res., 250k, $\pm 0.5\%$, 1/2W, metal	74 221 243 0
R007 A.B	Res., 900k, $\pm 0.5\%$, 1/2W, metal	74 221 231 0
R008 A.B	Res., 111k, $\pm 0.5\%$, 1/2W, metal	74 221 241 0
R009 A.B	Res., 990k, $\pm 0.5\%$, 1/2W, metal	74 221 232 0
R010 A.B	Res., 10.1k, $\pm 0.5\%$, 1/2W, metal	74 221 279 0
R011 A.B	Res., 999k, $\pm 0.5\%$, 1/2W, metal	74 221 233 0
R012 A.B	Res., 1,001k, $\pm 0.5\%$, 1/2W, metal	74 221 278 0
R013 A.B	Same as R002 A.B	
R014 A.B	Res., 100k, $\pm 0.5\%$, 1/2W, metal	74 221 239 0
R015 A.B	Same as R007 A.B	
R016 A.B	Res., 1M, $\pm 5\%$, 1/2W, carbon	74 241 113 0
R017 A.B	Res., 47, $\pm 2\%$, 1/2W, carbon	74 241 012 0
S001 A.B	Lever Switch (AC-GND-DC)	74 440 205 0
S002 A.B	Rotary Switch (VOLTS/DIV)	74 431 666 0
J001 A.B	BNC Connector, UG625/U-Ni.	74 500 253 0

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CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.
— VERTICAL AMPLIFIER —		
C100 A.B	Cap., 33 μ , +100%–10%, 25V, elect.	74 120 308 0
C101 A.B	Cap., 0.01 μ , +80%–20%, 25V, cer.	74 060 056 0
C102 A.B	Cap., 22 μ , +100%–10%, 16V, elect.	74 120 023 0
C103 A.B	Same as C101 A.B	
C104 A.B	Same as C101 A.B	
C105 A.B	Cap., 1000p, +80%–20%, 50V, cer.	74 060 175 0
C106 A.B	Same as C105 A.B	
C107 A.B	Cap., 8.5–30p, var., 250V, cer.	74 110 089 0
C108 A.B	Same as C105 A.B	
C109 A.B	Same as C105 A.B	
C111	Cap., 2200p, $\pm$ 10%, 50V, poly	74 130 196 0
C112	Same as C111	
C113	Cap., 3.5–10p, var., 250V, cer.	74 110 079 0
C114	Cap., 6–20p, var., 250V, cer.	74 110 073 0
C115	Cap., 5p, $\pm$ 0.5p, 50V, cer.	74 050 262 0
C116	Cap., 27p, $\pm$ 10%, 50V, cer.	74 050 576 0
C117	Same as C113	
C119	Same as C105 A.B	
C120	Same as C105 A.B	
C123	Cap., 10 μ , +100%–10%, 160V, elect.	74 120 105 0
C124	Same as C123	

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.
C125	Cap., 6800p, $\pm$ 10%, 50V, poly.	74 130 415 0
C126	Cap., 47p, $\pm$ 10%, 50V, cer.	74 050 273 0
C127	Same as C126	
C128	Cap., 100p, $\pm$ 10%, 50V, cer.	74 050 171 0
C129	Same as C101 A.B	
C130	Same as C101 A.B	
C131	Same as C101 A.B	
C144	Same as C102 A.B	
C145	Cap., 0.1 μ , +80%–20%, 25V, cer.	74 060 233 0
C146	Same as C145	
C147	Same as C101 A.B	
C148	Cap., 47 μ , +100%–10%, 16V, elect.	74 120 309 0
C149	Same as C102 A.B	
C150	Same as C101 A.B	
C151	Cap., 0.01 μ , +80%–20%, 25V, cer.	74 060 056 0
C152	Cap., 1000p, +100%–10%, 500V, cer.	74 060 070 0
C153	Same as C152	
C154 A.B	Same as C105 A.B	
C155 A.B	Cap., 0.1 μ , +80%–20%, 25V, cer.	74 060 233 0
C156	Same as C101 A.B	
C157	Cap., 0.05 μ , +80%–20%, 50V, cer.	
C158	Same as C151	
C160	Same as C115	
C161	Same as C101 A.B	

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.	CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.
C162	Same as C101 A.B		R123 A.B	Res., 500, var., 0.1W, carbon	74 349 210 0
R100 A.B	Res., 6.8k, $\pm 5\%$, 1/4W, carbon	74 223 209 0	R124 A.B	Res., 160, $\pm 5\%$, 1/4W, carbon	74 223 244 0
R101 A.B	Res., 47, $\pm 5\%$, 1/4W, compo.	74 253 007 0	R125 A.B	Same as R124 A.B	
R102 A.B	Res., 10k, var., 0.1W, carbon	74 349 206 0	R126 A.B	Res., 5.1k, $\pm 5\%$, 1/4W, carbon	74 223 206 0
R103 A.B	Res., 20k, $\pm 2\%$, 1/4W, metal	74 221 403 0	R127 A.B	Same as R126 A.B	
R104 A.B	Res., 910, $\pm 2\%$, 1/4W, metal	74 221 385 0	R128 A.B	Res., (10k+10k), var., 0.1W, carbon	74 322 058 0
R105 A.B	Res., 12k, $\pm 5\%$, 1/4W, carbon	74 223 215 0	R130	Res., 330, $\pm 2\%$, 1/4W, metal	74 221 377 0
R106 A.B	Same as R105 A.B		R131	Same as R130	
R107 A.B	Res., 100, $\pm 5\%$, 1/4W, carbon	74 223 3190	R132	Same as R111 A.B	
R108 A.B	Same as R100 A.B		R133	Res., 10k, var., 0.1W, metal	74 349 084 0
R109 A.B	Same as R100 A.B		R134	Res., 10k, $\pm 2\%$, 1/4W, metal	74 221 401 0
R110 A.B	Same as R107 A.B		R135	Res., 130, $\pm 5\%$, 1/4W, carbon	74 223 341 0
R111 A.B	Res., 2.2k, $\pm 2\%$, 1/4W, metal	74 221 438 0	R136	Same as R135	
R112 A.B	Same as R111 A.B		R137	Same as R122 A.B	
R113 A.B	Res., 100, $\pm 2\%$, 1/4W, metal	74 221 373 0	R138	Same as R122 A.B	
R114 A.B	Same as R107 A.B		R139	Res., 43, $\pm 5\%$, 1/4W, carbon	74 223 398 0
R115 A.B	Same as R107 A.B		R140	Same as R139	
R116 A.B	Res., 680, $\pm 2\%$, 1/4W, metal	74 221 382 0	R141	Res., 470, $\pm 2\%$, 1/4W, metal	74 221 450 0
R117 A.B	Same as R116 A.B		R142	Same as R141	
R118 A.B	Res., 360, $\pm 2\%$, 1/4W, metal	74 221 378 0	R143	Res., 200, $\pm 2\%$, 1/4W, metal	74 221 376 0
R120 A.B	Res., 1.5k, $\pm 2\%$, 1/4W, metal	74 221 388 0	R144	Res., 1.8k, $\pm 2\%$, 1/4W, metal	74 221 390 0
R121 A.B	Same as R120 A.B		R145	Same as R144 A.B	
R122 A.B	Res., 430, $\pm 2\%$, 1/4W, metal	74 221 380 0	R146	Res., 510, $\pm 2\%$, 1/4W, metal	74 221 381 0
			R147	Res., 75, $\pm 5\%$, 1/4W, carbon	74 223 399 0

SECTION 7 PARTS LIST

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.
R148	Same as R147	
R149	Res., 1.1k, $\pm 5\%$, 1/4W, carbon	74 223 191 0
R150	Same as R149	
R151	Res., 20k, var., 0.1W, metal	74 349 096 0
R152	Res., 2k, $\pm 5\%$, 1/4W, carbon	74 223 195 0
R153 A.B	Res., 20k, $\pm 2\%$, 1/2W, metal	74 221 444 0
R154 A.B	Same as R153 A.B	
R155	Res., 47k, $\pm 2\%$, 1/2W, carbon	74 241 081 0
R157	Res., 240, $\pm 5\%$, 1/4W, carbon	74 223 402 0
R158	Same as R157	
R159 A.B	Res., 18k, $\pm 2\%$, 1/2W, carbon	74 241 071 0
R160 A.B	Same as R159 A.B	
R161	Res., 360, $\pm 2\%$, 1/2W, carbon	74 241 033 0
R162	Res., 3k, $\pm 2\%$, 1/4W, metal	74 221 445 0
R163 A	Res., 500, var., 0.1W, metal	74 349 072 0
R163 B	Res., 2.7k, $\pm 2\%$, 1/4W, metal	74 221 392 0
R164	Res., 470k, $\pm 5\%$, 1/4W, carbon	74 223 334 0
R165	Res., 750, $\pm 5\%$, 1/4W, carbon	74 223 257 0
R166	Same as R164	
R167	Same as R165	
R168	Res., 68k, $\pm 5\%$, 1/4W, carbon	74 223 326 0
R169	Res., 3k, $\pm 5\%$, 1/4W, carbon	74 223 199 0
R170	Res., 10k, $\pm 5\%$, 1/4W, carbon	74 223 213 0
R171	Res., 1k, $\pm 5\%$, 1/4W, carbon	74 223 190 0

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.
R172	Res., 15k, $\pm 5\%$, 1/4W, carbon	74 223 268 0
R173	Res., 3.9k, $\pm 5\%$, 1/4W, carbon	74 223 202 0
R174	Res., 20k, $\pm 5\%$, 1/4W, carbon	74 223 217 0
R175	Res., 10, $\pm 5\%$, 1/4W, carbon	74 223 321 0
R176	Same as R171	
R177	Same as R171	
R178	Res., 510, $\pm 5\%$, 1/4W, carbon	74 223 252 0
R179	Res., 2.2, $\pm 5\%$, 1/4W, carbon	74 223 196 0
R180	Res., 10, $\pm 5\%$, 1/4W, carbon	74 223 321 0
R181	Same as R180	
R182	Same as R180	
R183	Res., 390, $\pm 2\%$, 1/2W, metal	74 221 451 0
R184	Res., 100, var., 0.1W, metal	74 349 074 0
R185	Same as R180	
R191	Res., 560, $\pm 5\%$, 1/4W, compo.	74 253 164 0
R192	Same as R191	
R193 A.B	Res., 300, var., 0.1W, carbon	74 322 259 0
< SS-4100G only >		
R194	Res., 100k, $\pm 5\%$, 1/4W, carbon	74 223 229 0
< SS-4100G only >		
IC101	Integrated Circuit, A6	74 570 014 0
IC102	Integrated Circuit, A12	74 570 010 0
D101 A.B	Diode, 1S1690 N	74 040 410 0

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.	CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.
D102 A.B	Same as D101 A.B		Q110	Same as Q101 A.B	
D103 A.B	Diode, 1S953	74 040 315 0	Q111	Same as Q101 A.B	
D104 A.B	Same as D103 A.B		Q112	Same as Q101 A.B	
D105	Same as D103 A.B		Q113	Same as Q101 A.B	
D106	Same as D103 A.B		Q114	Transistor, 2SC154C	74 030 400 0
D107	Z. Diode, RD7A	74 040 083 0	Q115	Same as Q114	
D108	Same as D103 A.B		Q116	Same as Q114	
D109	Same as D103 A.B		Q117	Same as Q114	
D110	Same as D103 A.B		Q118	Same as Q101	
D111	Same as D103 A.B		Q119	Same as Q101	
D112	Same as D103 A.B		NE101	Neon Lamp, NL2S	74 020 178 0
D113	Same as D103 A.B		NE102	Same as NE101	
D114 A.B	Same as D103 A.B		NE103	Same as NE101	
D115	Diode, 1S953	74 040 172 0	< SS-4100G only >		
D116	Same as D115		S101	Push Switch (POLARITY. PUSH. INVERT)	74 430 084 0
Q101 A.B	Transistor, 2SC1216 H	74 030 622 0	S102	Push Switch (MODE)	74 430 085 0
Q102 A.B	F E T, KH-5199, selected	74 030 645 0	DL101	Delay Line, CD-3	74 160 018 0
Q103 A.B	Same as Q102 A.B		J101	Multi-Connector	74 500 538 0
Q104 A.B	Same as Q101 A.B		P101	Multi-Connector	74 500 537 0
Q105 A.B	Same as Q101 A.B				
Q106 A.B	Transistor, 2N4034	74 030 615 0			
Q107 A.B	Same as Q106 A.B				
Q108 A.B	Same as Q101 A.B				
Q109 A.B	Same as Q101 A.B				

SECTION 7 PARTS LIST

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.
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—— TRIGGER AMPLIFIER ——

C201	Cap., 33 μ , +100%–10%, 16V, elect.	74 120 333 0
C203	Cap., 0.01 μ , +80%–20%, 25V, cer.	74 060 056 0
C204	Cap., 10 μ , +100%–10%, 16V, elect.	74 120 070 0
C205	Cap., 0.1 μ , +80%–20%, 25V, cer.	74 060 233 0
C206	Cap., 33p, $\pm$ 10%, 500V, cer.	74 050 250 0

< SS-4100 only >

C207	Cap., 0.01 μ , +100%–0%, 500V, cer.	74 060 073 0
C208	Cap., 68p, $\pm$ 10%, 500V, cer.	74 050 409 0

R201	Res., 6.8k, $\pm$ 5%, 1/4W, carbon	74 223 209 0
R202	Res., 10, $\pm$ 5%, 1/4W, compo.	74 253 044 0
R203	Res., 6.8k, $\pm$ 2%, 1/2W, carbon	74 241 062 0
R204	Res., 7.5k, $\pm$ 2%, 1/4W, metal	74 221 400 0
R205	Res., 1k, $\pm$ 2%, 1/4W, metal	74 221 386 0

R206	Res., 3.9k, $\pm$ 2%, 1/4W, metal	74 221 349 0
R207	Res., 1.6k, $\pm$ 2%, 1/4W, metal	74 221 389 0
R208	Res., 110, $\pm$ 2%, 1/4W, metal	74 221 374 0
R209	Res., 10k, $\pm$ 2%, 1/4W, metal	74 221 401 0
R210	Res., 1.5k, $\pm$ 5%, 1/4W, carbon	74 223 193 0

R211	Res., 1M, $\pm$ 5%, 1/4W, compo.	74 253 021 0
R212 A	Res., 680k, $\pm$ 2%, 1/2W, carbon	74 241 109 0

< SS-4100 only >

R212 B	Res., 100k, $\pm$ 5%, 1/4W, carbon	74 223 229 0
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CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.
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R213	Res., 470k, $\pm$ 2%, 1/2W, carbon	74 241 105 0
R214	Res., 820, $\pm$ 5%, 1/4W, carbon	74 223 264 0
R215	Res., 4.7k, $\pm$ 5%, 1/4W, carbon	74 223 204 0
R216	Res., 220, $\pm$ 5%, 1/4W, carbon	74 223 247 0
R217	Res., 1k, $\pm$ 5%, 1/4W, carbon	74 223 190 0

< R213 to R217 SS-4100G only >

R218	Res., 100, $\pm$ 5%, 1/4W, compo.	74 253 008 0
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D201	Diode, 1S 953	74 040 315 0
D202	Same as D201	
D203	Same as D201	
D204	Same as D201	
D205	Diode, D.A.P.4	

< SS-4100 only >

Q201	Transistor, 2SC 1216 H	74 030 622 0
Q202	Same as Q201	
Q203	Same as Q201	

S201	Push Switch (SOURCE)	74 430 089 0
S202	Push Switch (COUPLING)	74 430 086 0
S203	Slide Switch (NORM LOGIC)	74 430 060 0

TB201	Terminal Type, C9.5 ϕ BLACK (TRIG INPUT)	74 510 023 0
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TB202	Terminal, 8 ϕ (GND)	74 510 014 0
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CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.
J201	Multi-Connector	74 500 538 0
P201	Multi-Connector	74 500 535 0
— TRIGGER GENERATOR —		
C301	Cap., 0.01 μ , +80%–20%, 25V, cer.	74 060 056 0
C302	Same as C301	
C303	Same as C301	
C304	Cap., 0.1 μ , +80%–20%, 25V, cer.	74 060 233 0
C305	Cap., 1 μ , $\pm$ 20%, 100V, poly.	74 130 526 2
C306	Cap., 0.02 μ , +80%–20%, 25V, cer.	74 060 057 0
C307	Same as C306	
C308	Cap., 0.01 μ , +80%–20%, 25V, cer.	74 060 056 0
C309	Same as C308	
C310	Cap., 100p, $\pm$ 10%, 50V, cer.	74 050 171 0
C311	Same as C310	
C312	Cap., 4.7 μ , +100%–10%, 25V, elect.	74 120 017 0
C313	Same as C308	
C314	Cap., 22 μ , +100%–10%, 25V, elect.	74 120 494 0
C315	Cap., 22p, $\pm$ 10%, 50V, cer.	74 050 305 0
C316	Cap., 2200p, $\pm$ 10%, 50V, poly.	74 130 196 0
C318	Same as C312	
C319	Same as C314	
C320	Cap., 10 μ , +150%–10%, 25V, elect.	74 120 071 0

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.
L301	Peaking Coil, (E) 8T	74 400 355 0
L302	Coil, 14T	74 400 288 0
L303	Ferrite Bead, L820P-03.03-1H	74 560 009 0
R301	Res., 1M, $\pm$ 5%, 1/4W, compo.	74 253 021 0
R302	Same as R301	
R303	Res., 47, $\pm$ 5%, 1/4W, carbon	74 223 273 0
R304	Res., 4.3k, $\pm$ 2%, 1/2W, carbon	74 241 057 0
R305	Res., 1M, $\pm$ 5%, 1/4W, compo.	74 253 021 0
R306	Res., 4.3k, $\pm$ 5%, 1/4W, carbon	74 223 203 0
R307	Res., 6.2k, $\pm$ 5%, 1/4W, carbon	74 223 208 0
R308	Res., 500, var., 0.1W, metal	74 349 072 0
R309	Res., 3k, $\pm$ 5%, 1/4W, carbon	74 223 199 0
R310	Res., 200, $\pm$ 5%, 1/4W, compo.	74 253 037 0
R311(S301)	Res., 20k, var., 0.2W, carbon, selected	74 322 286 0
R312	Res., 1k, var., 0.1W, metal	74 349 071 0
R313	Res., 1.6k, $\pm$ 2%, 1/2W, carbon	74 241 047 0
R314	Res., 620, $\pm$ 2%, 1/2W, carbon	74 241 039 0
R315	Res., 22k, $\pm$ 5%, 1/4W, carbon	74 223 196 0
R316	Res., 1k, $\pm$ 2%, 1/2W, carbon	74 241 044 0
R317	Same as R308	
R318	Res., 6.8k, $\pm$ 5%, 1/4W, carbon	74 223 209 0
R319	Res., 13k, $\pm$ 5%, 1/4W, carbon	74 223 335 0
R320	Res., 47, $\pm$ 10%, 1/4W, compo.	74 253 028 0

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CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.	CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.
R321	Res., 68, $\pm 5\%$, 1/4W, carbon	74 223 412 0	IC302	Integrated Circuit, A4	74 570 012 0
R322	Res., 47, $\pm 5\%$, 1/4W, compo.	74 253 007 0			
R323	Res., 3k, $\pm 5\%$, 1/4W, carbon	74 223 199 0	D301	Diode 1S 953	74 040 315 0
R324	Res., 430, $\pm 5\%$, 1/4W, carbon	74 223 251 0	D302	Same as D301	
R325	Res., 82, $\pm 5\%$, 1/4W, compo.	74 253 081 0	D303	Same as D301	
			D304	Same as D301	
R326	Res., 100, $\pm 5\%$, 1/4W, compo.	74 253 008 0	D305	T. Diode, 1S1716	74 040 316 0
R327	Res., 18k, $\pm 5\%$, 1/4W, carbon	74 223 269 0			
R328	Res., 27, $\pm 5\%$, 1/4W, compo.	74 253 005 0	D306	Same as D301	
R329	Res., 15k, $\pm 5\%$, 1/4W, carbon	74 223 268 0	D307	Same as D301	
R330	Res., 10k, $\pm 5\%$, 1/4W, carbon	74 223 213 0	D308	Same as D301	
			D309	Same as D301	
R331	Res., 47, $\pm 5\%$, 1/4W, carbon	74 223 273 0	D310	Same as D301	
R332	Res., 100, $\pm 5\%$, 1/4W, carbon	74 223 319 0			
R333	Res., 5.1k, $\pm 5\%$, 1/4W, carbon	74 223 206 0	D311	Same as D301	
R334	Res., 4.7k, $\pm 5\%$, 1/4W, carbon	74 223 204 0	D312	Same as D301	
R335	Same as R334		D313	Same as D301	
R336	Res., 1k, $\pm 5\%$, 1/4W, carbon	74 223 190 0	Q301	F E T, 30088B/5007-1	74 030 808 3
R337	Res., 16k, $\pm 5\%$, 1/4W, carbon	74 223 345 0	Q302	Same as Q301	
R338	Res., 11k, $\pm 5\%$, 1/4W, carbon	74 223 331 0	Q303	Transistor, 2SC 1216H	74 030 622 0
R339	Res., 10, $\pm 5\%$, 1/4W, carbon	74 223 321 0	Q304	Same as Q303	
R340	Res., 20, $\pm 5\%$, 1/4W, compo.	74 253 026 0	Q305	Same as Q301	
R341	Res., 300, $\pm 5\%$, 1/4W, carbon	74 223 434 0	Q306	Transistor, 2N 4034	74 030 615 0
R342	Res., 47, $\pm 5\%$, 1/4W, compo.	74 253 007 0	Q307	Same as Q306	
			Q308	Same as Q303	
IC301	Integrated Circuit, A7	74 570 004 0			

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.
T301	Transformer, 8T-8T	74 400 467 0
T302	Same as T301	
S302	Push Switch (MODE)	74 430 097 0
RL301	Relay, NR-HD-12V	74 450 150 0
P301	Multi-Connector	74 500 537 0
J301	Multi-Connector	74 500 538 0

—— A SWEEP GENERATOR ——

C400	Cap., 0.1 μ , +80%–20%, 25V, cer.	74 060 233 0
C401	Same as C400	
C402	Cap., 22 μ , +100%–10%, 25V, elect.	74 120 494 0
C403	Same as C400	
C404	Cap., 56p, $\pm$ 10%, 50V, cer.	74 050 272 0
C405	Cap., 10 μ , +100%–10%, 50V, elect.	74 120 311 0
C406	Cap., 1000p, +80%–20%, 50V, cer.	74 060 175 0
C407	Cap., 27p, $\pm$ 10%, 500V, cer.	74 050 204 0
C408	Cap., 470p, $\pm$ 10%, 50V, cer.	74 050 243 0
C409	Cap., 27p, $\pm$ 10%, 50V, cer.	74 050 276 0
C410	Cap., 47p, $\pm$ 10%, 50V, cer.	74 050 273 0
C412	Same as C400	
C415	Same as C406	

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.
C416	Cap., 36p, $\pm$ 5%, 50V, cer.	74 050 585 0
C417	Cap., 220 μ , +100%–10%, 16V, elect.	74 120 220 0
C481	Cap., 0.01 μ , +80%–20%, 25V, cer.	74 060 056 0
C482	Cap., 150p, $\pm$ 1%, 50V, cer.	74 050 301 0
R400	Res., 10, $\pm$ 5%, 1/4W, compo.	74 253 044 0
R401	Res., 10, $\pm$ 5%, 1/4W, carbon	74 223 321 0
R402	Same as R401	
R403	Same as R401	
R404	Res., 130, $\pm$ 5%, 1/4W, carbon	74 223 341 0
R405	Res., 3.9k, $\pm$ 2%, 1/4W, metal	74 221 394 0
R406	Res., 3k, $\pm$ 5%, 1/4W, carbon	74 223 199 0
R407	Res., 1.6k, $\pm$ 2%, 1/4W, metal	74 221 389 0
R408	Res., 500, var., 0.1W, metal	74 349 072 0
R409	Res., 100, $\pm$ 5%, 1/4W, compo.	74 253 008 0
R410	Res., 3k, $\pm$ 2%, 1/4W, metal	74 221 445 0
R411	Res., 390, $\pm$ 2%, 1/4W, metal	74 221 379 0
R412	Res., 820, $\pm$ 2%, 1/4W, metal	74 221 384 0
R413	Res., 1k, $\pm$ 5%, 1/4W, carbon	74 223 190 0
R414	Res., 510, $\pm$ 5%, 1/4W, carbon	74 223 252 0
R415	Res., 7.5k, $\pm$ 2%, 1/4W, metal	74 221 400 0
R416	Same as R401	
R417	Res., 820, $\pm$ 5%, 1/4W, carbon	74 223 264 0
R418	Res., 560, $\pm$ 5%, 1/4W, carbon	74 223 253 0
R419	Res., 330, $\pm$ 1%, 1/4W, metal	74 221 409 0

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CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.	CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.
R420	Res., 620, $\pm 1\%$, 1/4W, metal	74 221 410 0	R445	Same as R418	
R421	Same as R414		R447	Res., 10, $\pm 5\%$, 1/4W, carbon	74 223 321 0
R422	Res., 1.5k, $\pm 5\%$, 1/4W, carbon	74 223 193 0	R448	Res., 1.3k, $\pm 2\%$, 1/4W, metal	74 221 446 0
R423	Res., 47, $\pm 5\%$, 1/4W, compo.	74 253 007 0	R449	Same as R411	
R425	Res., 20k, $\pm 5\%$, 1/4W, carbon	74 223 217 0	R450	Same as R400	
R426	Same as R409		R453	Res., 100, $\pm 20\%$, 1/4W, compo.	74 253 085 0
R427	Same as R409		R455	Res., 200, $\pm 5\%$, 1/4W, metal	74 230 134 0
R428	Res., 6.2k, $\pm 1\%$, 1/4W, metal	74 221 398 0	R479	Res., 130k, $\pm 5\%$, 1/4W, carbon	74 223 327 0
R429	Res., 330, $\pm 2\%$, 1/4W, metal	74 221 337 0	R481	Res., 100k, $\pm 5\%$, 1/4W, carbon	74 223 229 0
R430	Res., 10k, $\pm 5\%$, 1/2W, metal	74 230 248 0	R482	Res., 51k, $\pm 5\%$, 1/4W, carbon	74 223 225 0
R431	Same as R430		R483	Res., 15k, $\pm 5\%$, 1/4W, carbon	74 223 268 0
R432	Res., 20k, $\pm 2\%$, 1/4W, metal	74 221 403 0	R484	Res., 33k, $\pm 5\%$, 1/4W, carbon	74 223 324 0
R433	Res., 10k, var., 0.1W, carbon	74 322 249 0	R485	Res., 4.7M, $\pm 5\%$, 1/4W, compo.	74 253 163 0
R434	Res., 13k, $\pm 5\%$, 1/4W, carbon	74 223 335 0	R486	Res., 270, $\pm 5\%$, 1/4W, carbon	74 223 270 0
R435	Res., 75k, $\pm 5\%$, 1/4W, carbon	74 223 228 0	R487	Res., 10k, $\pm 5\%$, 1/4W, carbon	74 223 213 0
R436	Same as R405		R488	Res., 51k, $\pm 5\%$, 1/4W, compo.	74 253 161 0
R437	Res., 2k, $\pm 2\%$, 1/4W, metal	74 221 391 0	R489	Res., 1M, $\pm 5\%$, 1/4W, compo.	74 253 021 0
R438	Res., 240, $\pm 5\%$, 1/4W, carbon	74 223 402 0	< R479 to R489 SS-4100G only >		
R439	Res., 5.1k, $\pm 2\%$, 1/4W, metal	74 221 396 0	D401	Diode, 1S 953	74 040 315 0
R440	Res., 4.3k, $\pm 2\%$, 1/4W, metal	74 221 439 0	D402	T. Diode, 1S 1716	74 040 316 0
R441	Same as R412		D403	Same as D401	
R442	Res., 1k, $\pm 2\%$, 1/4W, metal	74 221 386 0	D404	Same as D401	
R443	Same as R439		D405	Diode, 1S 1458	74 040 292 0
R444	Same as R442				

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.
D406	Same as D401	
D407	Same as D401	
D408	Same as D401	
D481	Same as D401	
D482	Same as D401	
D483	Same as D401	
D484	Same as D401	
< D481 to D484 SS-4100G only >		
Q401	Transistor, 2N 4034	74 030 615 0
Q402	Transistor, 2SC 1216 H	74 030 622 0
Q403	Same as Q402	
Q404	F E T, 30088C/5007-2	74 030 808 4
Q405	Same as Q402	
Q406	Same as Q402	
Q407	Same as Q402	
Q408	Same as Q401	
Q409	Same as Q401	
Q481	Transistor, 2SC 857	74 030 427 0
< SS-4100G only >		
S401	Push Switch, SB-2061	74 430 001 0
S403(NE401)	Push Switch, PCN-5	74 430 024 0
< SS-4100 only >		
J401	Multi-Connector	74 500 538 0

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.
P401	Multi-Connector	74 500 535 0

—— B SWEEP GENERATOR ——

C501	Cap., 56p, $\pm 10\%$, 50V, cer.	74 050 272 0
C502	Cap., 51p, $\pm 5\%$, 50V, cer.	74 050 552 0
C503	Cap., 200p, $\pm 5\%$, 50V, cer.	74 050 175 0
C504	Cap., 0.1 μ , +80%–20%, 25V, cer.	74 060 233 0
C505	Cap., 1000p, +80%–20%, 50V, cer.	74 060 175 0
C507	Cap., 27p, $\pm 10\%$, 500V, cer.	74 050 204 0
C508	Cap., 15p, $\pm 10\%$, 50V, cer.	74 050 173 0
C509	Same as C504	
C510	Cap., 4.7 μ , +100%–10%, 25V, elect.	74 120 017 0
C511	Same as C510	
C512	Same as C504	
C513	Same as C504	
C514	Same as C504	
C515	Cap., 36p, $\pm 5\%$, 50V, cer.	74 050 585 0
C516	Cap., 0.047 μ , +80%–20%, 25V, cer.	74 060 122 0
C517	Cap., 0.01 μ , +80%–20%, 25V, cer.	74 060 056 0
C518	Cap., 8p, $\pm 1p$, 50V, cer.	74 050 560 0
R501	Res., 20k, $\pm 2\%$, 1/4W, metal	74 221 403 0
R502	Res., 1.5k, $\pm 2\%$, 1/4W, metal	74 221 388 0

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CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.
R503	Res., (50k+10k), var., 1/8W, carbon, selected	74 322 250 0
R504	Same as R503	
R505	Res., 30k, $\pm 2\%$, 1/4W, metal	74 221 405 0
R506	Res., 10k, var., 0.5W, W.W.	74 331 063 0
R507	Same as R506	
R508	Res., 6.8k, $\pm 5\%$, 1/4W, carbon	74 223 209 0
R509	Res., 1.5k, $\pm 5\%$, 1/4W, carbon	74 223 193 0
R510	Res., 750, $\pm 5\%$, 1/4W, carbon	74 223 257 0
R511	Res., 2.7k, $\pm 5\%$, 1/4W, carbon	74 223 198 0
R512	Res., 9.1k, $\pm 5\%$, 1/4W, carbon	74 223 212 0
R513	Res., 820, $\pm 2\%$, 1/4W, metal	74 221 384 0
R514	Res., 100, $\pm 5\%$, 1/4W, compo.	74 253 008 0
R515	Res., 200, $\pm 5\%$, 1/4W, compo.	74 253 037 0
R516	Res., 240, $\pm 2\%$, 1/4W, metal	74 221 455 0
R517	Res., 3k, $\pm 2\%$, 1/4W, metal	74 221 445 0
R518	Res., 130, $\pm 5\%$, 1/4W, carbon	74 223 341 0
R519	Res., 3.9k, $\pm 2\%$, 1/4W, metal	74 221 394 0
R520	Res., 2.4k, $\pm 2\%$, 1/4W, metal	74 221 423 0
R521	Res., 500, var., 0.1W, metal	74 349 072 0
R522	Same as R510	
R523	Res., 82, $\pm 2\%$, 1/4W, metal	74 221 469 0
R524	Res., 560, $\pm 5\%$, 1/4W, carbon	74 223 253 0
R525	Res., 390, $\pm 2\%$, 1/4W, metal	74 221 379 0

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.
R526	Res., 100, $\pm 5\%$, 1/4W, carbon	74 223 319 0
R527	Same as R510	
R528	Res., 510, $\pm 5\%$, 1/4W, carbon	74 223 252 0
R529	Res., 820, $\pm 5\%$, 1/4W, carbon	74 223 264 0
R530	Same as R521	
R531	Res., 620, $\pm 1\%$, 1/4W, metal	74 221 410 0
R532	Same as R528	
R533	Same as R509	
R535	Res., 47, $\pm 5\%$, 1/4W, compo.	74 253 007 0
R536	Same as R514	
R537	Same as R514	
R538	Res., 20k, $\pm 5\%$, 1/4W, carbon	74 223 217 0
R539	Res., 6.2k, $\pm 2\%$, 1/4W, metal	74 221 415 0
R540	Res., 12k, $\pm 5\%$, 1/4W, metal	74 230 249 0
R541	Same as R540	
R542	Res., 3.9k, $\pm 1\%$, 1/4W, metal	74 221 414 0
R543	Res., 2k, $\pm 1\%$, 1/4W, metal	74 221 412 0
R545	Res., 240, $\pm 5\%$, 1/4W, carbon	74 223 402 0
R546	Same as R505	
R547	Res., 7.5k, $\pm 2\%$, 1/4W, metal	74 221 400 0
R548	Res., 10, $\pm 5\%$, 1/4W, carbon	74 223 321 0
R550	Same as R548	
R551	Res., 10, $\pm 5\%$, 1/4W, compo.	74 253 044 0
R552	Same as R548	

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.
R553	Res., 2k, $\pm 2\%$, 1/4W, metal	74 221 391 0
R554	Res., 16k, $\pm 2\%$, 1/4W, metal	74 221 443 0
R555	Res., 20k, $\pm 5\%$, 1/4W, carbon	74 223 217 0
R556	Same as R555	
R557	Same as R509	
D501	Diode, 1S 953	74 040 315 0
D502	Same as D501	
D503	Same as D501	
D504	Same as D501	
D505	Same as D501	
D506	T. Diode, 1S1761	74 040 316 0
D507	Same as D501	
D508	Diode, 1S1458	74 040 292 0
D509	Diode, 1S1198	74 040 238 0
Q501 A.B	Transistor, μ PA 35A	74 030 551 0
Q503	Transistor, 2N4034	74 030 615 0
Q504	Same as Q503	
Q505	Transistor, 2SC 1216 H	74 030 622 0
Q506	Same as Q503	
Q507	Same as Q505	
Q508	Same as Q505	
Q509	Same as Q505	
Q510	F E T, 30088C/5007-2	74 030 808 4
Q511	Same as Q505	

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.
S501	Push Switch (HORIZ DISPLAY)	74 430 089 0
S502	Push Switch (PUSH TRIG)	74 430 084 0

—— A & B TIMING SWITCHES ——

C413 A	Cap., 1 μ , $\pm 0.25\%$, 50V, poly.	74 130 498 0
C413 B	Cap., 100p, $\pm 10\%$, 50V, cer.	74 050 171 0
C413 C	Cap., 0.1 μ , $\pm 0.25\%$, 50V, poly.	74 130 497 0
C413 D	Cap., 0.01 μ , $\pm 0.25\%$, 50V, poly.	74 130 496 0
C413 E	Cap., 0.01 μ , $\pm 0.25\%$, 50V, poly.	74 130 495 0
C413 F	Cap., 5.5 – 25p, var., 250V, cer.	74 110 011 0
C413 G	Cap., 82p, $\pm 5\%$, 100V, mica	74 090 510 0
C413 H	Same as C413 F	
C413 I	Same as C413 G	
C414 A	Cap., 22 μ , +100%-10%, 25V, elect.	74 120 494 0
C414 B	Cap., 3.3 μ , +100%-10%, 50V, elect.	74 120 325 0
C414 C	Cap., 0.22 μ , $\pm 10\%$, 50V, poly.	74 130 237 0
C414 D	Cap., 0.1 μ , +80%-20%, 25V, cer.	74 060 233 0
C414 F	Cap., 0.0047 μ , $\pm 10\%$, 50V, poly.	74 130 132 0
C414 G	Cap., 470p, $\pm 10\%$, 50V, cer.	74 060 195 0
C414 H	Cap., 150p, $\pm 10\%$, 50V, cer.	74 050 301 0
C506 A	Same as C413 A	
C506 B	Same as C413 B	
C506 C	Same as C413 C	
C506 D	Same as C413 D	

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.
C506 E	Same as C413 E	
C506 F	Same as C413 F	
C506 G	Same as C413 G	
C506 H	Same as C413 F	
C506 I	Same as C413 G	
R452 A.B	Res., 8.25M, $\pm 0.5\%$, 1/2W, metal	74 221 422 0
R452 C	Res., 5.5M, $\pm 0.5\%$, 1/2W, metal	74 221 421 0
R452 D	Res., 2.75M, $\pm 0.5\%$, 1/2W, metal	74 221 420 0
R452 E	Res., 1.65M, $\pm$, 1/2W, metal	74 221 419 0
R452 F	Res., 550k, $\pm 0.5\%$, 1/2W, metal	74 221 418 0
R452 G	Res., 539k, $\pm 0.5\%$, 1/2W, metal	74 221 417 0
R452 H	Res., 264k, $\pm 0.5\%$, 1/2W, metal	74 221 416 0
R452 I	Res., 11k, $\pm 0.5\%$, 1/2W, metal	74 221 351 0
R490	Res., 5.1k, $\pm 2\%$, 1/4W, metal	74 221 396 0
R491	Res., 3k, var., 0.1W, carbon	74 349 211 0
R492	Res., 10k, $\pm 2\%$, 1/4W, metal	74 221 401 0
R493	Res., 50k, var., 0.1W, carbon	74 322 260 0
< SS-4100G only >		
R494	Res., 100k, $\pm 5\%$, 1/4W, carbon	74 223 229 0
< SS-4100 only >		
R534 A.B	Same as R452 A.B	
R534 C	Same as R452 C	
R534 D	Same as R452 D	
R534 E	Same as R452 E	

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.
R534 F	Same as R452 F	
R534 G	Same as R452 G	
R534 H	Same as R452 H	
R534 I	Same as R452 I	
R590	Res., 6.2k, $\pm 2\%$, 1/4W, metal	74 221 415 0
R591	Same as R491	
R592	Same as R492	
NE401	Neon Lamp, NL 2S	74 020 178 0
S402 A.B	Rotary Switch, S32M(24)4-7-19S, S32M(24)3-6-19/F	74 431 664 0
HORIZONTAL AMPLIFIER		
C601	Cap., 0.01 μ , +80%-20%, 25V, cer.	74 060 056 0
C602	Same as C601	
C603	Same as C601	
C604	Same as C601	
C605	Same as C601	
C606	Cap., 10p, $\pm 1p$, 50V, cer.	74 050 170 0
C607	Cap., 10 μ , +100%-10%, 160V, elect.	74 120 105 0
C608	Same as C607	

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.
C609	Cap., 100 μ , +100%-10%, 25V, elect.	74 120 088 0
C610	Same as C601	
C611	Cap., 220 μ , +100%-10%, 16V, elect.	74 120 220 0
L601	Ferrit Bead, L820p-03.03-1H	74 560 009 0
R601	Res., 3k, $\pm 1\%$, 1/4W, metal	74 221 413 0
R602	Res., 51k, $\pm 5\%$, 1/4W, carbon	74 253 161 0
R603	Res., 1.5k, $\pm 5\%$, 1/4W, carbon	74 223 193 0
R604	Same as R603	
R605	Same as R602	
R606	Same as R601	
R607	Res., 2.2k, $\pm 2\%$, 1/4W, metal	74 221 438 0
R608	Res., 500, var., 0.1W, metal	74 349 072 0
R609	Res., 22k, $\pm 2\%$, 1/4W, metal	74 221 449 0
R610	Res., 5k, var., 0.1W, metal	74 349 055 0
R612	Res., 12k, $\pm 5\%$, 1/4W, carbon	74 223 215 0
R613(S601)	Res., (10k+50k), var., 0.25W, carbon (POSITION) with Switch, selected	74 325 295 0
R614	Res., 150k, $\pm 5\%$, 1/4W, carbon	74 223 231 0
R615	Same as R613 (FINE)	
R616	Res., 47, $\pm 5\%$, 1/4W, compo.	74 253 007 0
R617	Res., 6.8k, $\pm 5\%$, 1/4W, compo.	74 253 113 0
R618	Same as R616	
R619	Res., 10k, $\pm 5\%$, 1/4W, carbon	74 223 213 0

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.
R620	Res., 2.2, $\pm 5\%$, 1/4W, compo.	74 253 001 0
R621	Res., 2k, $\pm 2\%$, 1/4W, metal	74 221 391 0
R622	Res., 500, var., 0.1W, metal	74 349 072 0
R623	Res., 6.8k, $\pm 2\%$, 1/4W, metal	74 221 399 0
R624	Res., 2k, var., 0.1W, carbon	74 349 214 0
R625	Res., 680, $\pm 2\%$, 1/4W, carbon	74 223 255 0
R626	Res., 3.6k, $\pm 2\%$, 1/4W, metal	74 221 393 0
R627	Res., 20k, $\pm 2\%$, 1/4W, metal	74 221 403 0
R629	Res., 100k, $\pm 2\%$, 1/4W, metal	74 221 406 0
R630	Res., 180, $\pm 5\%$, 1/4W, carbon	74 223 245 0
R631	Res., 100, $\pm 5\%$, 1/4W, carbon	74 223 319 0
R632	Res., 1.5k, $\pm 2\%$, 1W, carbon	74 242 032 0
R633	Res., 100k, $\pm 2\%$, 1/2W, carbon	74 241 089 0
R634	Res., 1M, $\pm 5\%$, 1/4W, compo.	74 253 021 0
R635	Same as R634	
R636	Res., 470, $\pm 5\%$, 1/4W, compo.	74 253 049 0
R637	Res., 390, $\pm 5\%$, 1/4W, carbon	74 223 250 0
R638	Res., 2k, $\pm 5\%$, 1/4W, carbon	74 223 195 0
R639	Res., 100k, $\pm 5\%$, 1/4W, carbon	74 223 229 0
R640	Res., 200k, $\pm 2\%$, 1/4W, metal	74 221 407 0
R641	Same as R609	
R642	Same as R640	

SECTION 7 PARTS LIST

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.
R643	Same as R630	
R644	Res., 10k, $\pm 2\%$, 1/2W, carbon	74 241 066 0
R645	Res., 68k, $\pm 2\%$, 1/2W, carbon	74 241 085 0
R646	Same as R634	
R647	Same as R634	
R649	Res., 5.1k, $\pm 5\%$, 1/4W, carbon	74 223 206 0
R650	Res., 10, $\pm 5\%$, 1/4W, compo.	74 253 044 0
R652	Res., 10, $\pm 5\%$, 1/4W, carbon	74 223 321 0
R653	Res., 10, $\pm 5\%$, 1/4W, metal	74 230 007 0
D601	Diode, 1S953	74 040 315 0
D602	Same as D601	
D603	Same as D601	
D604	Same as D601	
D606	Same as D601	
D607	Same as D601	
D608	Diode, 1S955	74 040 184 0
D609	Same as D608	
D610	Same as D601	
D611	Same as D601	
D612	Same as D608	
D613	Same as D608	
Q601	Transistor, 2SC 1216 H	74 030 622 0
Q602	Transistor, 2N 4034	74 030 615 0

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.
Q603	Same as Q601	
Q604	Transistor, 2SC 154 C	74 030 400 0
Q605	Same as Q604	
Q606	Same as Q601	
Q607	Same as Q604	
Q608	Same as Q604	
RL601	Relay, RE 0113	74 450 145 0
J601	Multi-Connector	74 500 538 0
P601	Multi-Connector	74 500 535 0

— Z AXIS AMPLIFIER —

C701	Cap., 20p, $\pm 5\%$, 50V, cer.	74 050 528 0
C702	Cap., 0.1 μ , +80%–20%, 25V, cer.	74 060 233 0
C703	Cap., 0.01 μ , +80%–20%, 25V, cer.	74 060 056 0
C704	Same as C703	
C705	Same as C703	
C706	Cap., 0.05 μ , +80%–20%, 25V, cer.	74 060 298 0
C707	Same as C706	
C708	Same as C703	
C709	Same as C702	
C710	Same as C702	

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.	CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.
C711	Cap., 47p, $\pm 10\%$, 50V, cer.	74 050 273 0	R723	Same as R718	
C712	Same as C702		R724	Res., 20k, $\pm 2\%$, 1/4W, metal	74 221 403 0
			R725	Same as R717	
R701	Res., 100k, $\pm 2\%$, 1/2W, carbon	74 241 089 0	R726	Same as R718	
R702	Res., 910k, $\pm 2\%$, 1/2W, carbon	74 241 112 0	R727	Res., 62k, $\pm 2\%$, 1/4W, metal	74 221 537 0
R703	Res., 1M, $\pm 5\%$, 1/4W, compo.	74 253 021 0			
R704	Res., 6.8k, $\pm 5\%$, 1/4W, carbon	74 223 209 0	R728	Res., 10k, $\pm 5\%$, 1/4W, carbon	74 223 321 0
R705	Res., 4.3k, $\pm 5\%$, 1/4W, carbon	74 223 203 0	R729	Same as R728	
			R730	Res., 10k, $\pm 2\%$, 1/4W, metal	74 221 401 0
R706	Res., 100, $\pm 5\%$, 1/4W, carbon	74 223 319 0	R731	Res., 47, $\pm 20\%$, 1/4W, compo.	74 253 075 0
R707	Res., 75, $\pm 2\%$, 1/2W, carbon	74 241 086 0			
R708	Res., 240, $\pm 5\%$, 1/4W, carbon	74 223 402 0	D701	Diode, 1S 953	74 040 315 0
R709	Res., 100k, $\pm 2\%$, 1/4W, metal	74 221 406 0	D702	Same as D701	
R710	Res., 3k, $\pm 5\%$, 1/4W, carbon	74 223 199 0	D703	Same as D701	
			D704	Same as D701	
R712	Same as R710		D705	Same as D701	
R713	Res., 12k, $\pm 2\%$, 1/4W, metal	74 221 424 0			
R714	Res., 5k, var., 0.1W, metal	74 349 055 0	D706	Same as D701	
R715	Res., 18k, $\pm 2\%$, 1/4W, metal	74 221 536 0	D707	Same as D701	
R716	Same as R714		D708	Same as D701	
			D709	Same as D701	
R717	Res., 51k, $\pm 5\%$, 1/4W, carbon	74 223 225 0	D710	Same as D701	
R718	Res., 2k, $\pm 5\%$, 1/4W, carbon	74 223 195 0			
R719	Same as R706		D711	Same as D701	
R720	Same as R706				
R721	Same as R706		Q701	F E T, 30088B/5007-1	74 030 808 3
			Q702	Transistor, 2SC 154C	74 030 400 0
R722	Same as R717		Q703	Same as Q703	

SECTION 7 PARTS LIST

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.
Q704	Transistor, 2SC 1216 H	74 030 622 0
TB701	Terminal, Type C9.5φ BLACK	74 510 023 0
TB702	Same as TB701	
—— C.R.T CIRCUIT ——		
C800	Cap., 0.005μ, +100%–0%, 3KV, cer.	74 060 275 0
C801	Cap., 0.22μ, ±10%, 50V, poly.	74 130 237 0
C802	Cap., 0.01μ, +80%–20%, 50V, cer.	74 060 058 0
C803	Cap., 0.047μ, ±10%, 50V, poly.	74 130 201 0
C804	Cap., 220μ, +100%–10%, 25V, elect.	74 120 264 0
C805	Cap., 0.0022μ, +100%–0%, 6KV, cer.	74 060 202 0
C806	Same as C805	
C807	Cap., 0.005, +100%–0%, 3KV, cer.	74 060 275 0
C808	Same as C807	
C809	Same as C807	
C810	Cap., 0.01μ, +100%–0%, 500V, cer.	74 060 073 0
C811	Same as C810	
C812	Cap., 5000p, +100%–0%, 2KV, cer.	74 060 197 0
C813	Cap., 0.01μ, +100%–0%, 500V, cer.	74 060 073 0
C815	Same as C813	
R801	Res., 47k, var., 0.15W, compo.	74 345 044 0
R802	Res., 4.7M, ±5%, 1/4W, compo.	74 281 008 0
R803	Res., 1.2M, ±5%, 1/4W, compo.	74 281 018 0

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.
R804	Res., 10k, ±5%, 1/4W, carbon	74 223 213 0
R805	Res., 47k, ±5%, 1/4W, carbon	74 223 224 0
R806	Res., 51k, ±5%, 1/4W, carbon	74 223 225 0
R807 A	Res., 3.3M, ±5%, 1/4W, compo.	74 281 006 0
R807 B	Same as R807 A	
R807 C	Same as R807 A	
R807 D	Res., 3.3M, ±5%, 1/4W, compo.	74 281 006 0
R807 E	Same as R807 D	
R807 F	Same as R807 D	
R807 G	Same as R807 D	
R808	Res., 100k, ±5%, 1/4W, carbon	74 223 229 0
R809	Res., 20k, ±5%, 1/4W, carbon	74 223 217 0
R810	Res., 39k, ±5%, 1/4W, metal	74 230 078 0
R811	Res., 100k, ±5%, 1/4W, metal	74 230 026 0
R812	Res., (2M+1M), var., 1/4W, carbon, selected	74 323 068 0
R813	Res., 430k, ±5%, 1/2W, carbon	74 241 104 0
R814	Res., 2.7, ±5%, 1/4W, compo.	74 281 004 0
R815	Same as R812 (FOCUS)	
R816	Res., 620k, ±2%, 1/2W, carbon	74 241 108 0
R817 A	Res., 1.5M, ±5%, 1/4W, compo.	74 281 001 0
R817 B	Same as R817 A	
R817 C	Same as R817 A	
R817 D	Same as R817 A	

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.
R818	Res., 100k, var., 0.1W, carbon	74 349 213 0
R819	Same as R804	
R820	Same as R804	
R821	Same as R818	
R822	Res., 2.2, $\pm 5\%$, 1/4W, carbon	74 223 219 0
R823	Res., 62k, $\pm 5\%$, 1/4W, carbon	74 223 226 0
R824	Res., 3k, $\pm 5\%$, 1/4W, carbon	74 223 199 0
R825	Res., 100, $\pm 5\%$, 1/4W, carbon	74 223 319 0
R826	Res., 5k, var., 0.1W, carbon	74 349 212 0
R827	Same as R825	
R828	Res., 3k, $\pm 2\%$, 1/2W, carbon	74 241 053 0
R829	Res., 130k, $\pm 5\%$, 1/4W, carbon	74 223 327 0
R831	Res., 51, $\pm 5\%$, 1/4W, metal	74 230 060 0
R851	Res., 470, $\pm 5\%$, 1/4W, carbon	74 223 263 0
IC801	Integrated Circuit, A-2	74 570 002 0
D801	Diode, HF SD-1	74 040 314 0
D802	Z. Diode, HW 91A	74 040 324 0
D803	Diode, VF 5-7X	74 040 438 0
D804	Diode, VF 5-12X	74 040 356 0
D805	Same as D804	
D806	Z. Diode, HW51A	74 040 302 0
D807	Z. Diode, HW30A	74 040 321 0
D808	Diode, RD19A	74 040 094 0

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.
Q801	Transistor, 2SD 93	74 030 376 0
V801	Cathode Ray Tube, H8503C-B31	74 010 137 0
F801	Fuse, 1A (6.2 ϕ x 30l) (Fuse Holder)	74 540 006 0 74 480 158 0
T801	High Voltage Transformer OSC. (Ferrite Core, EI-50)	74 472 101 0 74 560 062 0
J801	Multi-Connector	74 500 538 0
P801	Multi-Connector	74 500 537 0

—— POWER SUPPLY ——

C901	Cap., 10 μ , +100%–10%, 250V, elect.	74 120 002 0
C902	Cap., 40 μ , +100%–10%, 160V, elect.	74 120 527 0
C903	Same as C902	
C904	Cap., 330 μ , +100%–10%, 25V, elect.	74 120 324 0
C905	Same as C904	
C906	Same as C904	
C907	Same as C904	
C908	Cap., 0.01 μ , +80%–20%, 25V, cer.	74 060 056 0
C909	Cap., 3.3 μ , +75%–15%, 100V, elect.	74 120 544 0
C910	Cap., 10 μ , +100%–10%, 100V, elect.	74 120 485 0

SECTION 7 PARTS LIST

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.	CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.
C911	Same as C908		R919	Res., 500, var., 0.75W, W.W.	74 331 077 0
C913	Cap., 47 μ , +100%–10%, 16V, elect.	74 120 309 0	R920	Res., 33k, $\pm 5\%$, 1/2W, metal	74 230 344 0
C916	Same as C908		R921	Res., 0.6, $\pm 10\%$, 1W, W.W.	74 228 062 0
C917	Cap., 4.7 μ , +100%–10%, 16V, elect.	74 120 448 0	R922	Res., 2.7k, $\pm 5\%$, 1/4W, carbon	74 223 315 0
C918	Same as C913		R923	Res., 1.2k, $\pm 2\%$, 1/4W, metal	74 221 440 0
C919	Cap., 4700p, $\pm 20\%$, 500V, cer.	74 060 299 0	R924	Res., 620, $\pm 2\%$, 1/4W, metal	74 221 441 0
C921	Cap., 0.01 μ , +80%–20%, 25V, cer.	74 060 056 0	R925	Res., 1k, $\pm 2\%$, 1/4W, metal	74 221 386 0
C981	Cap., 0.33 μ , $\pm 20\%$, 50V, poly.	74 130 352 0	R926	Same as R919	
< SS-4100G only >			R927	Same as R915	
R901	Res., 50, var., 1.5W, W.W., selected	74 331 048 0	R928	Res., 56k, $\pm 5\%$, 1/4W, carbon	74 223 322 0
R902	Res., 100k, $\pm 2\%$, 1/2W, carbon	74 241 089 0	R929	Res., 3.3k, $\pm 5\%$, 1/4W, carbon	74 223 200 0
R903	Res., 200k, $\pm 5\%$, 1/4W, carbon	74 223 232 0	R930	Res., 560k, $\pm 5\%$, 1/4W, carbon	74 223 343 0
R904	Res., 100k, $\pm 5\%$, 1/4W, carbon	74 223 229 0	R931	Same as R921	
R905	Same as R904		R932	Same as R915	
R909 A	Res., 12k, $\pm 5\%$, 1/2W, metal	74 230 249 0	R933	Same as R919	
R909 B	Res., 13k, $\pm 5\%$, 1/2W, metal	74 230 335 0	R934	Res., 910, $\pm 2\%$, 1/4W, metal	74 221 385 0
R911	Res., 39k, $\pm 5\%$, 1/4W, carbon	74 223 222 0	R935	Res., 200, $\pm 5\%$, 1/4W, metal	74 230 134 0
R912	Res., 2, $\pm 10\%$, 1W, W.W.	74 228 099 0	R936	Same as R935	
R913	Res., 33k, $\pm 5\%$, 1/4W, carbon	74 241 077 0	R981	Res., 1k, $\pm 5\%$, 1/4W, carbon	74 223 190 0
R914	Res., 13k, $\pm 5\%$, 1/4W, carbon	74 223 335 0	R982	Res., 15k, $\pm 5\%$, 1/4W, carbon	74 223 268 0
R915	Res., 2.4k, $\pm 5\%$, 1/4W, metal	74 230 022 0	R983	Res., 4.7k, $\pm 5\%$, 1/4W, carbon	74 223 204 0
R916	Res., 62k, $\pm 5\%$, 1/4W, carbon	74 223 226 0	< R981 to R983 SS-4100G only >		
R917	Res., 30k, $\pm 5\%$, 1/2W, metal	74 230 357 0			
R918	Res., 2k, $\pm 5\%$, 1/4W, metal	74 230 041 0			

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.	CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.
IC901	Integrated Circuit, A-1	74 570 001 0	F901	Fuse, 0.25A (5.2 ϕ x20l)	74 540 027 0
IC902	Same as IC901		F902	Same as F901	
IC903	Same as IC901		F903	Same as F901	
D901	Silicon stack, M4G-1	74 040 398 0	S901	Push Switch, Ytipe 3510-21P.P	74 430 090 0
D902	Same as D901		S902	Toggle Switch, MST-206N	74 430 037 0
D903	Silicon stack, M4E-1	74 040 389 0	T901	Power Transformer	74 471 264 0
D904	Silicon stack, M4C-1	74 040 388 0	J901	Multi-Connector	74 500 538 0
D905	Same as D904		J902	Same as J901	
D906	Diode, RD7A	74 040 083 0	P901	Multi-Connector	74 500 535 0
D907	Diode, 1S 953	74 040 315 0	P902	Same as P901	
D908	Z. Diode, 1S 2191	74 040 451 0	U901	Power cord, U-81030	74 470 171 0
Q901	Transistor, 2SC 685 A	74 030 385 0	— CALIBRATOR —		
Q902	Transistor, MJE 1100	74 030 642 0			
Q903	Same as Q902				
NE901	Neon Bracket Lamp, BNF-3	74 020 177 0			
HM901	Timer, TM-0	74 470 207 0			
PL901	Scale Illumination Lamp, 6.3V 150mA (Socket, E-5)	74 490 015 0 74 480 131 0)	C1001	Cap., 100 μ , +100%-10%, 16V, elect.	74 120 302 0
F900	Fuse, 1A(Slow Blow)(5.2 ϕ x20l) (Fuse Holder, AC 250V 2A)	74 540 042 0 74 480 095 0)	C1002	Same as C1001	
			C1003	Cap., 0.47 μ , $\pm$ 10%, 50V, poly.	74 130 201 0
			C1004	Cap., 1000p, +100%-0%, 500V, poly.	74 060 070 0
			C1005	Same as C1003	
			R1001	Res., 2.2, $\pm$ 5%, 1/4W, compo.	74 253 001 0
			R1003	Same as R1001	
			R1004	Res., 1.98k, $\pm$ 0.25%, 1/4W, metal	74 221 533 0

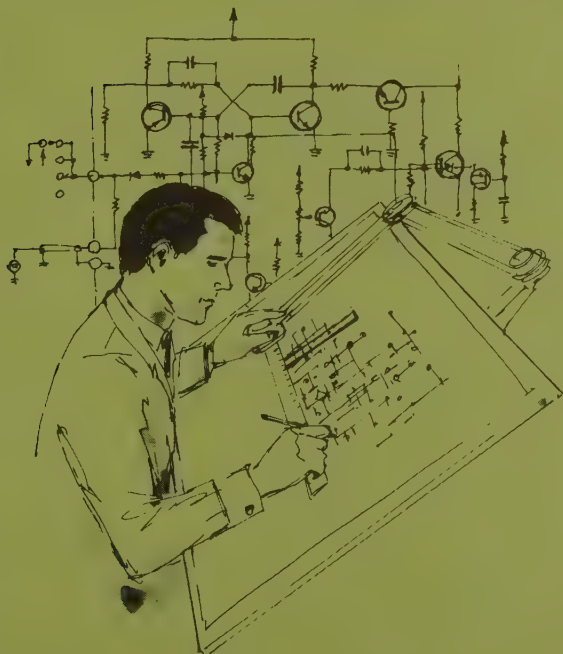
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CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.	CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.
R1005	Res., 1k, $\pm 0.25\%$, 1/4W, metal	74 221 532 0	PB203	Printed Circuit Board (CNT.PB)	74 41 870 03
R1006	Res., 29.7k, $\pm 0.25\%$, 1/4W, metal	74 221 534 0	PB301	Printed Circuit Board (HORIZONTAL)	74 41 739 08
R1007	Same as R1006		PB302	Printed Circuit Board (FULL AUTO)	74 41 742 06
R1008	Res., 100, $\pm 0.25\%$, 1/4W, metal	74 221 535 0	PB401	Same as PB203	
R1009	Same as R1008		PB601	Printed Circuit Board (FLX.PB) A	74 41 737 04
R1010	Res., 510, $\pm 5\%$, 1/4W, metal	74 230 045 0	PB801	Printed Circuit Board (H.V. CIRCUIT 1)	74 41 743 02
R1011	Same as R1010		PB802	Printed Circuit Board (H.V. CIRCUIT 2)	74 41 744 02
R1012	Res., 10, $\pm 5\%$, 1/4W, carbon	74 223 321 0	PB803	Same as PB203	
IC1001	Integrated Circuit, AY-40	74 570 042 0	PB901	Same as PB203	
X1001	Piezo — fork, EFM-S1000Hz	74 450 029 0	PB902	Printed Circuit Board (FLX.PB) B	74 41 736 03
—— PRINTED CIRCUIT BOARD ——					
PB101	Printed Circuit Board (VERTICAL)	74 41 738 08			
PB201	Printed Circuit Board (TRIG AMP)	74 41 740 07			
PB202	Printed Circuit Board (COUPLING)	74 41 741 05			

8

SECTION 8 DIAGRAMS

This section covers schematic diagrams and other illustrations required for calibration and maintenance of the SS-4100/SS-4100G, including explanation of schematic symbols.



CIRCUIT LOCATION DIAGRAMS (PHOTOS)	8-2
SCHEMATIC SYMBOLS OF CIRCUIT	
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ATTENUATOR	
VERTICAL AMPLIFIER	
TRIGGER AMPLIFIER	
A SWEEP GENERATOR	
B SWEEP GENERATOR	
A & B TIMING SWITCHES	
HORIZONTAL AMPLIFIER	
Z AXIS AMPLIFIER	
CRT CIRCUIT	
POWER SUPPLY	
CALIBRATOR	

CIRCUIT LOCATION DIAGRAMS (PHOTOS)

Figure 8-1 Top View

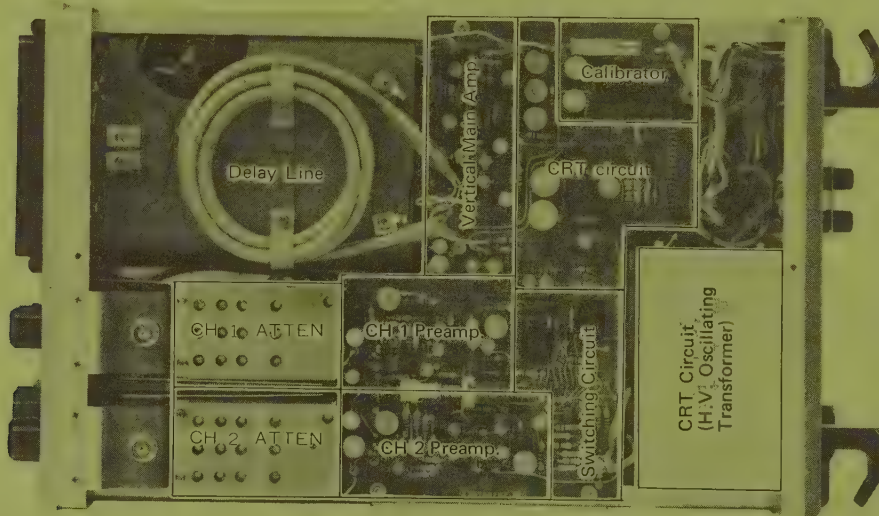


Figure 8-2 Bottom View

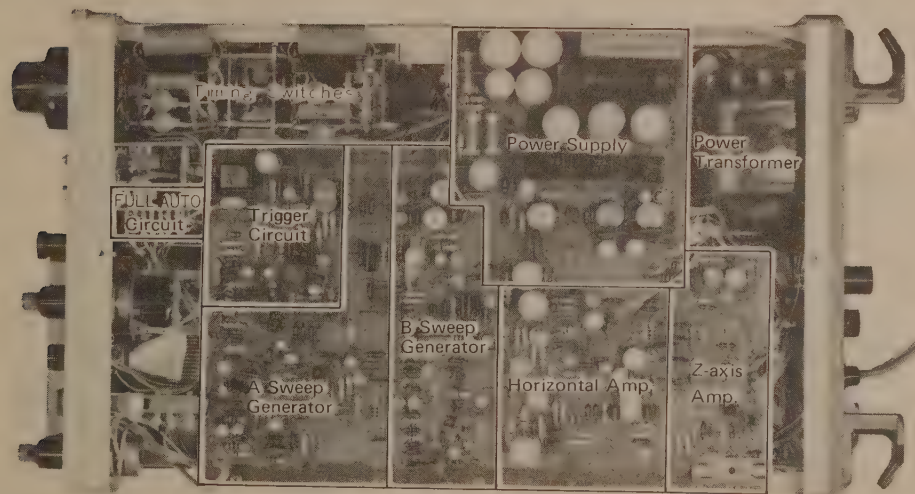
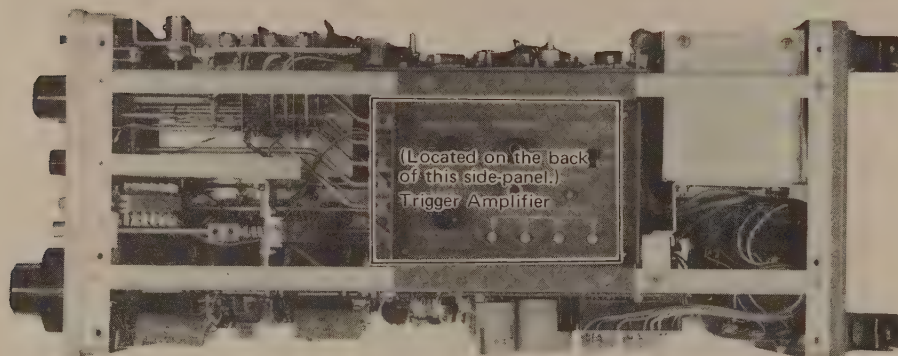
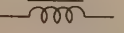
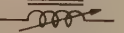


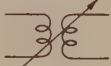
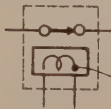
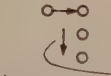
Figure 8-3 Right Side View



SCHEMATIC SYMBOLS OF CIRCUIT COMPONENTS

IWATSU has established schematic symbols of circuit components as shown in Table 8-1. These symbols are used throughout this instruction manual.

Component	Abbreviation	Symbol
Resistor	R	 Fixed
		 Variable
		 Variable (clockwise rotation)
		 Thermistor
Capacitor	C	 Fixed
		 Variable
		 Electrolytic (polar)
		 Electrolytic (non-polar)
Coil	L	 Fixed
		 Variable
		 With Core (fixed)
		 With Core (variable)

Component	Abbreviation	Symbol
Transformer	T	 Fixed Coupling
		 Fixed Coupling (coil start indicated)
		 Variable Coupling
		 With Core
		 Power, High Voltage Transformer
Relay	RL	 Coil Start Indicated (coil start dot)
Switch	S	 2-terminal Type
		 Rotary Lever (clockwise rotation)
		 Pushbutton (pushed state)
Thermal Switch	TH	

Component	Abbreviation	Symbol
Transistor	Q	 General
		 Twin Type
		 With Heat Sink
		 With Thermal Coupling
		 FET MOS Type
		 FET JUNCTION Type
Diode	D	 General
		 Zener
		 Tunnel
		 SCR
		 Illuminative

Component	Abbreviation	Symbol
Diode Stack	D	
Integrated Circuit	IC	 1 — 8 Denote Electrodes.
CRT Tube	V	
Pilot Lamp	PL	
Neon Lamp	NE	
Resonator	X	 Piezo-fork
		 Crystal
Motor	M	
Hour Meter	HM	

Component	Abbreviation	Symbol
Fuse	F	 R: Rapid Blow S: Slow Blow
Battery	B	
Probe Loop		 (direction of current)
Power Cord	U	
Coaxial Cable	W	
Multi-connector	P, J	 Plugs (P) and Jacks (J)  Jacks only
Multi-plug of Printed Board	P	
Coaxial Cable Connector	P, J	 Jack (J)  Plug (P)

Component	Abbreviation	Symbol
Terminal (binding post)	TB	
Test Point	TP	
Printed Board	PB	
Semi-fixed		
To be adjusted		
Ground		
Wiring		 Connected  Unconnected  To be connected
Panel		

Measuring units (Ω , F, H) of resistors, capacitors and coils are omitted in diagrams.

EXPLANATION OF SPECIAL SYMBOLS

Switch Wafers

The wafers of a rotary switch used in the SS-4100/SS-4100G are indicated on the schematic diagram by denoting the front side of the 1st wafer (the one closest to the front panel of the synchroscope) by A-F, the rear side of the 1st wafer by A-R, the front side of the 2nd wafer by B-F, the rear side of the 2nd wafer by B-R, and so forth. Similarly, the wafers of a coaxial gang switch are indicated by denoting the wafer of the 1st switch (the one closest to the front panel) by aA-F, aA-R, that of the 2nd switch by bA-F, bA-R, and so forth.

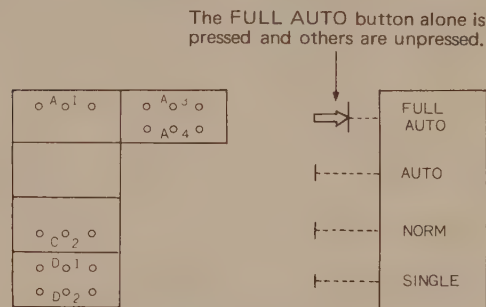
Pushbutton Switches

As a general rule the pushbutton switch is indicated as in the unpushed state. A set of linked pushbutton switches, however, is indicated under the state that the one which is most frequently used is being pressed. The left hand drawing of Fig. 8-4 shows terminals of the corresponding switches shown in the right hand drawing.

Destination Symbols

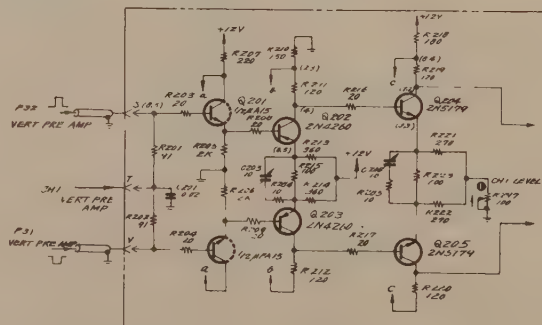
To prevent schematic circuit diagram from becoming badly complicated, arrow marks and alphabetic letters may be used as shown in the example illustrated in Fig. 8-5.

Figure 8-4 Symbols for Pushbutton Switch



Example for SS-4100G

Figure 8-5 Example of Destination Symbol



SCHEMATIC DIAGRAMS

Circuit voltages and waveforms indicated in the schematic diagrams are, as a general rule, as measured or observed by setting the switches and controls as mentioned below.

Exceptions are indicated by "VOLTAGE & WAVEFORM READING CONDITIONS" on respective schematic diagrams. Partial change in condition is indicated by asterisk.

— Power Supply and CRT Circuit —

INTENSITY	Adequate brightness
FOCUS	Good focusing
POWER (PUSH ON)	Pushed state
SCALE ILLUM	Arbitrary

— Vertical Deflection System —

AC-GND-DC (CH 1 and 2)	GND
VOLTS/DIV (CH 1 and 2)	CAL 4 V
VARIABLE (CH 1 and 2)	CALIB
<SS-4100G only>	
POSITION (CH 1 and 2)	As the waveform is displayed in graticule center.
CH 2 POLARITY (PUSH INV)	Unpushed state
MODE	CH 1

— Horizontal Deflection System —

HORIZ DISPLAY	A
B MODE (PUSH TRIG)	Unpushed state
A TIME/DIV	1 mSEC
A VARIABLE	CALIB
<SS-4100G only>	
B TIME/DIV	1 mSEC
SWEEP STOP	Unpushed state
A SWEEP LENGTH	Fully clockwise
DELAY TIME	Fully counterclockwise
POSITION	Waveform start aligned with graticule left hand end.
(PULL x 10 MAG) FINE	Pushed, mid-position

— Trigger Circuit —

SOURCE	INT CH 1
SWEEP MODE	AUTO
COUPLING	AC
(PUSH+ SLOPE) LEVEL	Pushed. Properly triggering state.
(PUSH- SLOPE) LEVEL	NORM
EXT TRIG SELECTOR	
<SS-4100 only>	
TRIG SELECTOR	EXT
<SS-4100G only>	



0V 50mV/DIV



+2.5V 0.2V/DIV



4V 0.5V/DIV



1.2mS/DIV



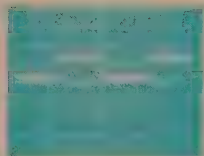
1V/DIV



1V/DIV



0.2mS/DIV



0.2mS/DIV



★ ★



1V/DIV



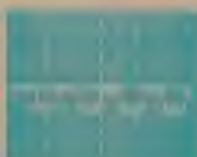
5V/DIV



0.2mS/DIV



2μS/DIV



2μS/DIV



★ ★

★

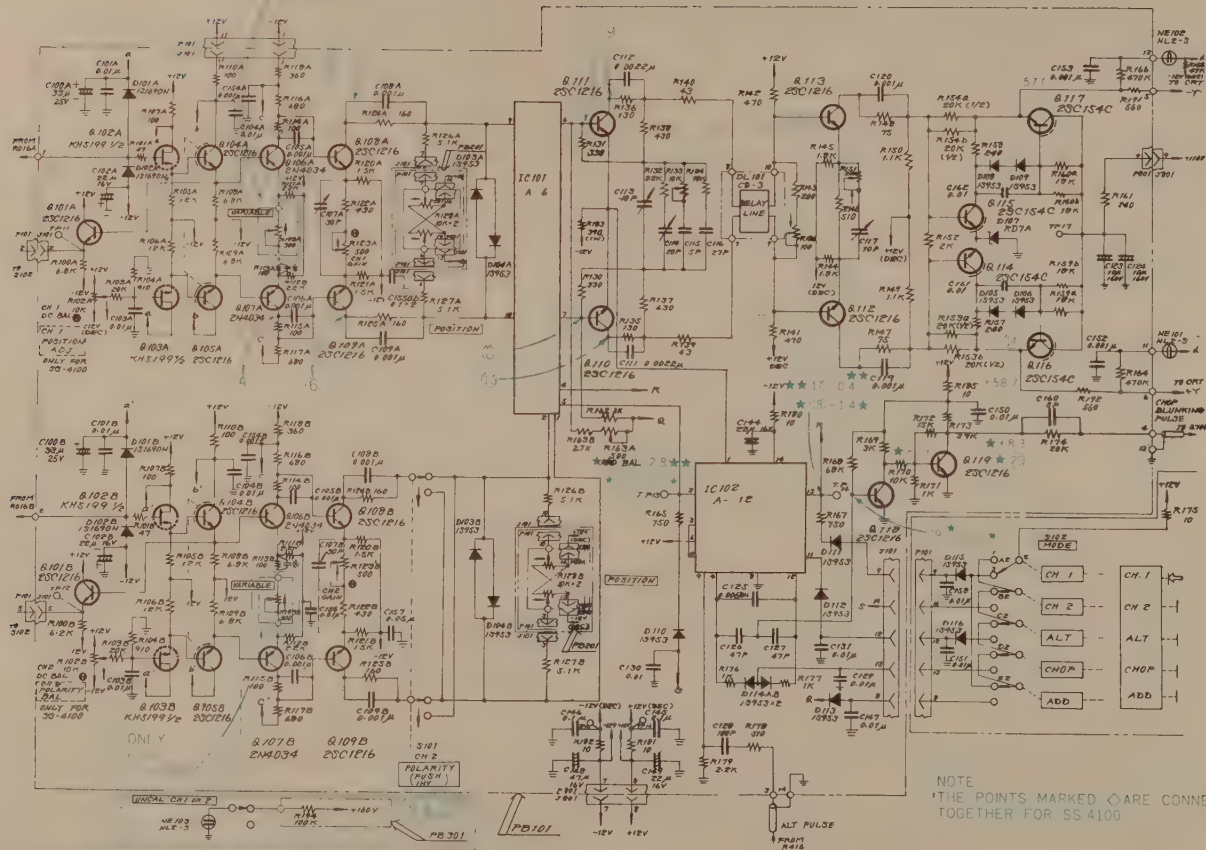
★

★

VOLTAGE & WAVEFORM READING CONDITIONS

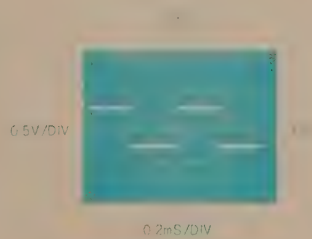
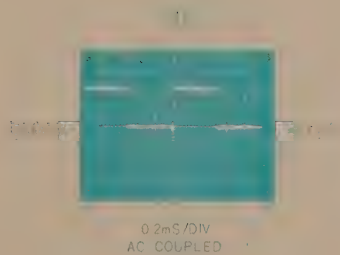
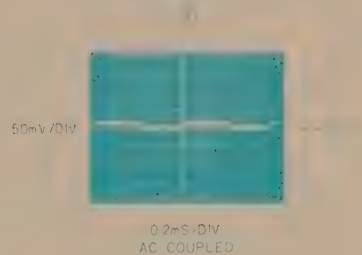
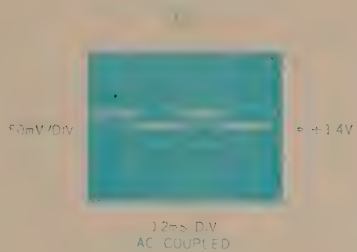
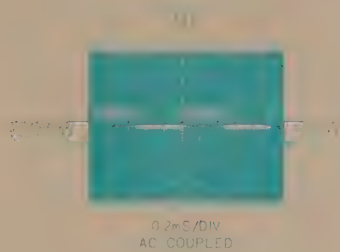
★ MODE CHOP

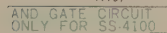
★ ★



VERTICAL AMPLIFIER

K-605446-5





TRIGGER AMPLIFIER



0.5V/DIV



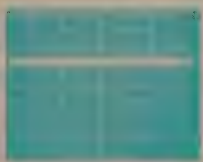
0.5V/DIV



0V

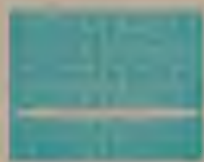
0.2ms/DIV
AC COUPLED

2ms/DIV



0.5V/DIV

0.2ms/DIV



0.2V/DIV

0.2ms/DIV



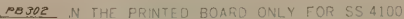
5V/DIV

1ms/DIV



VOLTAGE & WAVEFORM READING CONDITION:

- ★ LEVEL.....Non triggered
- ★★ SWEEP MODE.....FULL AUTO



A SWEEP GENERATOR



10 DIV



10 DIV



10 DIV



5mS/DIV
AC COUPLED



5mS/DIV



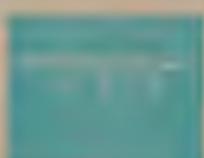
5mS/DIV



2V/DIV



5mS/DIV



5mS/DIV



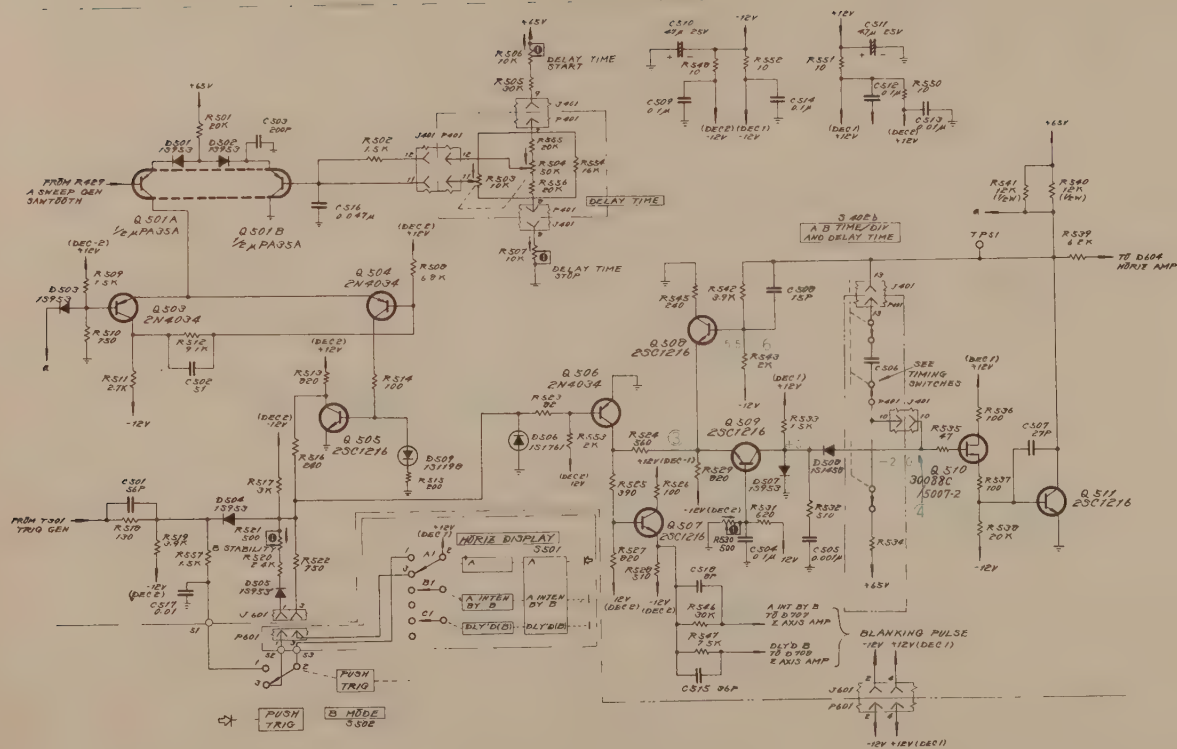
10 DIV

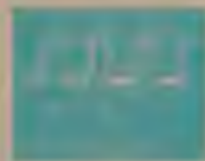
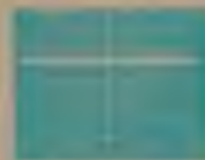


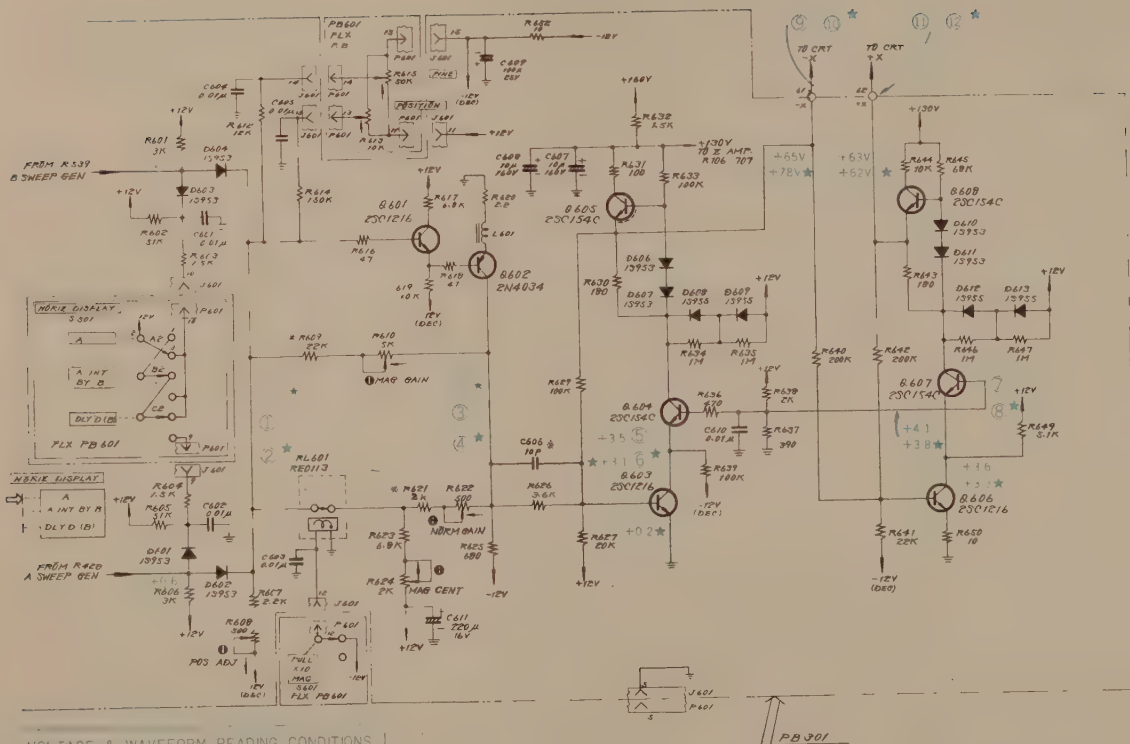
5mS/DIV
AC COUPLED

VOLTAGE & WAVEFORM PEAKING CONDITIONS
HORIZ. DISPLAY-----DLY'D B

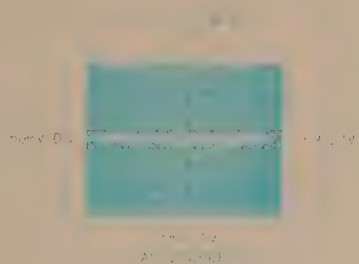
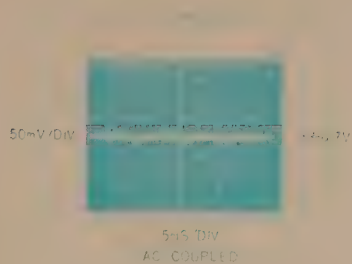
B SWEEP GENERATOR







HORIZONTAL AMPLIFIER



WAVEFORM & WAVEFORM READING CONDITIONS

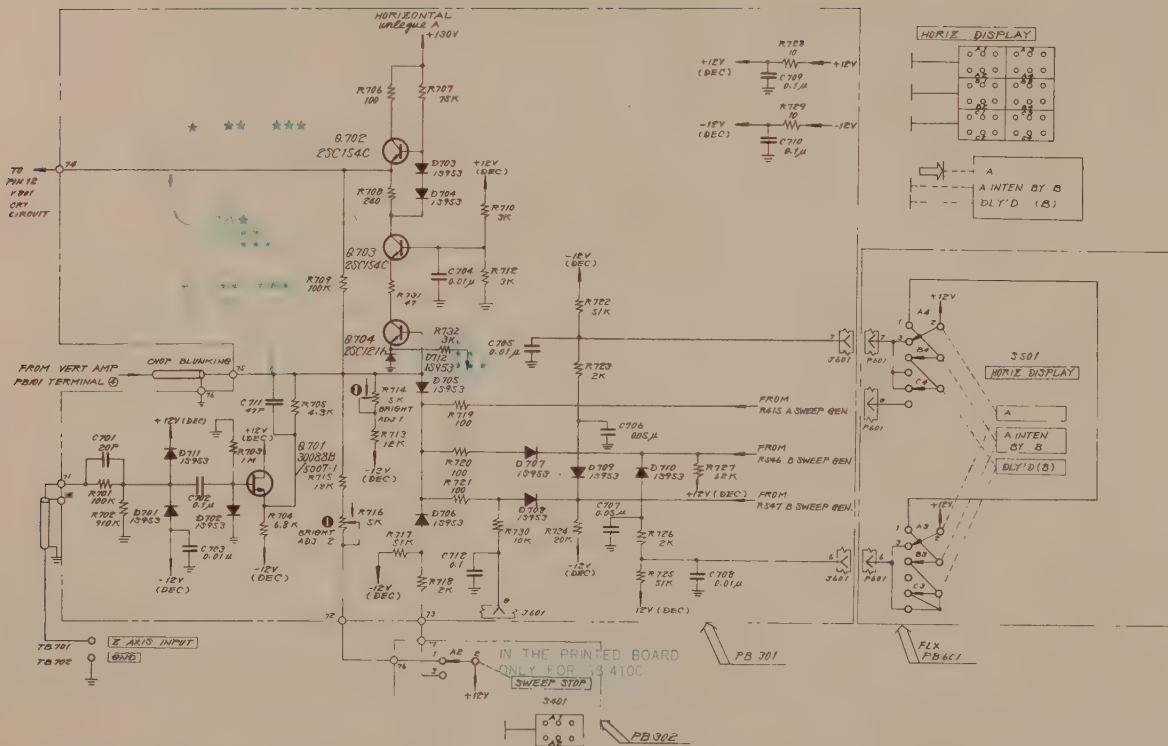
DELAY TIME.....0.000000

B.T.M.L. DIV.....2.000000

★HOLD / DISPLAY.....AINTBYB

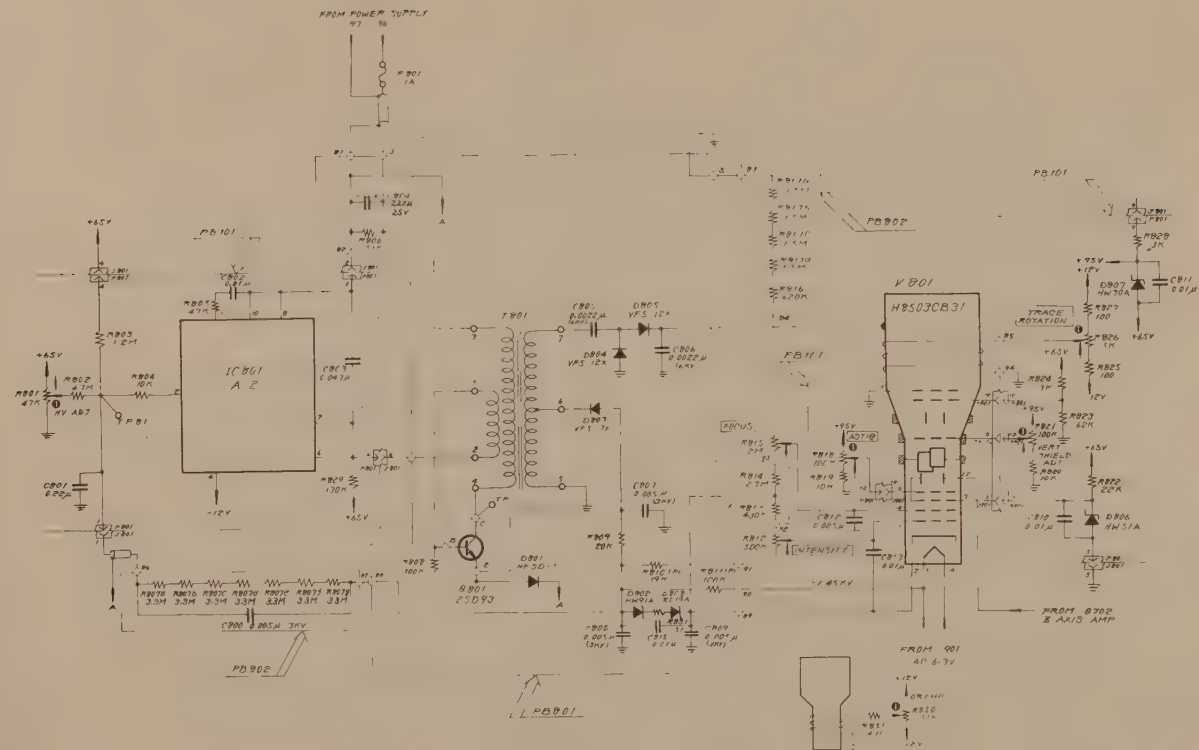
★★HOLD / DISPLAY.....DLY C.H

★★★MODE.....CHOP



Z AXIS AMPLIFIER





C.R.T CIRCUIT

K -605455- 4



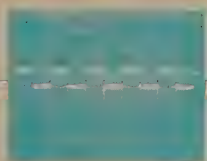
2V·DIV



10V·DIV



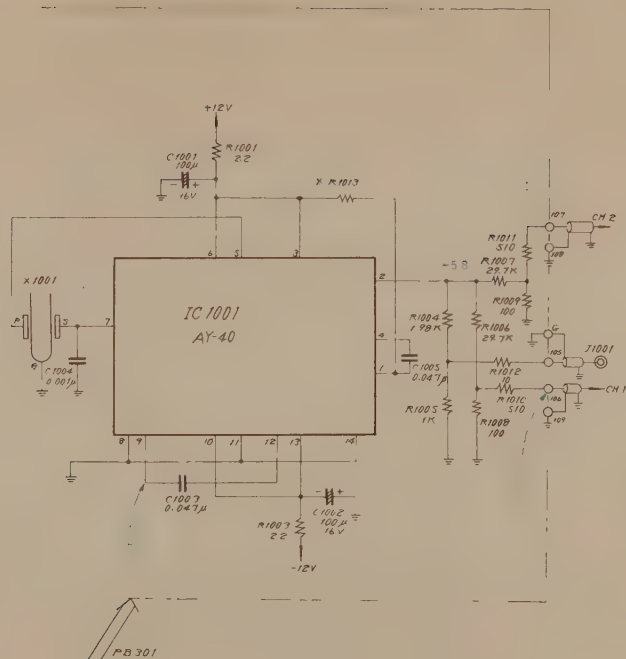
2V·DIV



2V·DIV



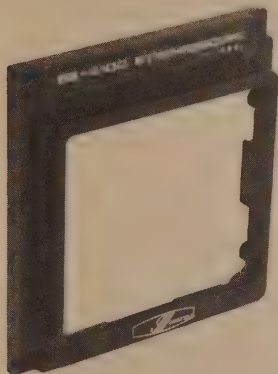
0.5ms·DIV



OPTIONAL ACCESSORIES

The below-mentioned optional accessories are available from IWATSU for further improvement in convenience in handling and for further expansion of application such as photographing of displayed waveforms.

For details of these optional accessories, contact our representative in your area.



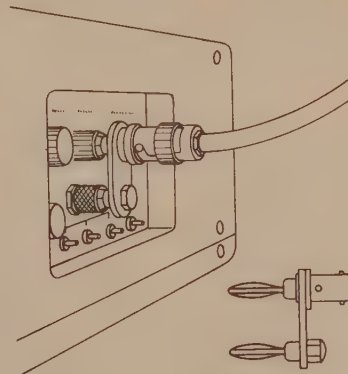
CAMERA-MOUNT BEZEL

A universal-purpose camera mount for photographing of displayed waveforms is available from IWATSU. To use this camera mount, the regular bezel of the synchroscope must be replaced with this camera-mount bezel. Incidentally, note that the filter screen should be removed for photographing the displayed waveforms.



SHOULDER BAND

The SS-4100/SS-4100G can be conveniently carried by using this shoulder band (see Fig. 2-1 a). To carry the synchroscope, connect the two ends of the band to the brackets of the synchroscope and adjust the band to a convenient length.



BNC CONVERSION TIPS

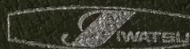
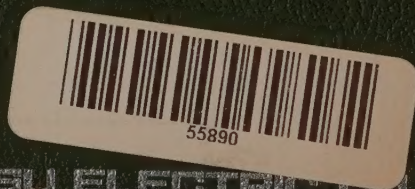
This conversion tips is used to connect the TRIG INPUT terminal (for SS-4100) or EXT TRIG INPUT terminal (for SS-4100G), or Z AXIS INPUT terminal to a BNC input connector. The above illustration shows an example of connecting the TRIG INPUT terminal to a BNC connector.

MEMO

NOTICE OF MODIFICATION OF INSTRUCTION MANUAL

To keep the instruments' performances and reliabilities always in the state-of-the-art, instruments are modified occasionally. In the case a new instruction manual to follow a new modification is not immediately available due to delay in printing work, etc., the user will be informed of the modification with a notice covered in an envelope of this style.

MEMO



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